ELECTRICAL REVIEW

ILLUSTRATED.

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VIEWS, NEWS AND INTERVIEWS.

With apologies to "Brick" Pomeroy, the following is offered: "The Electric Light and Health are sworn partners."

"I recall," said an electrical inventor, "that about 20 years ago I had one of the largest electrical libraries in the United States. It consisted of five volumes. In looking over the ELECTRICAL REVIEW book catalogue, the other day, I noticed the titles of nearly 400 electrical books. Of such is the kingdom of progress."

The gold medal given to Virchow on his seventieth birthday is the largest ever made. It weighs nearly six pounds, and the metal alone is worth $1,750.

In this country there are on record as having accepted the government act and voluntarily submitting to the right of the postmaster-general to fix rates, no less than 98 different telegraph companies. And yet in sending a message it must be accepted by either the Western Union Telegraph Company or the Postal Telegraph Cable Company. The longest distance for which a charge is made is 3,530 miles, from Olympia, Wash., to Augusta, Me.

Jules Verne writes his extraordinary stories in a little room crowded with charts, electrical apparatus and scientific instruments. Even in his most imaginary flights he keeps as close as he can to the line of scientific possibility.

The newness of Governor Flower to the executive chamber at Albany was made apparent by his failure to find the electric call-bells which are used to summon the clerks and messengers from the outer offices. But he was not above walking across the executive chamber, opening the door and summoning by word of mouth the clerk he wanted.

The greatest surprise in Queen Victoria's New Year's honors is the peerage for Sir William Thomson. His researches into electrical science have made for Sir William a world-wide name. Recently when Mr. Balfour delivered his rectoral address at Glasgow University he was the guest of Sir William, and doubtless the conferment of a peerage is due to Balfour's initiation. Sir William is a genial, homely Scotchman. He is above all suspicion. No amount of money could buy from him a favorable opinion for an unworthy object. He is slightly lame, and walks with the aid of a thick oaken stick. He dresses more for comfort than show, and his care of the bawbees is frequently illustrated by his contentions with London cabmen. He is said to have a knack of gauging how far he can ride for a shilling to a mathematical nicety.

A thief, who has for a long time in all probability been stealing incandescent electric lamps at the Paris theatres, has just been arrested by a clever device of the management of the Porte St. Martin. As it was found that a great many lamps had disappeared at that house, the electrical engineer so arranged the fittings that immediately a lamp was removed the electric current sounded an alarm. The man was thus caught as he was making away with a lamp in his pocket, and as he refuses his name and address to the police, it is believed that he has a large store somewhere of the stolen articles.

The London Gaslight and Coke Company asserts that it has beaten the record in its line during Christmas week when fog and frost reigned for six awful days and nights. On one day alone the company's customers consumed 128,000,000 cubic feet of gas. Thirteen thousand tons of coal were burnt by the company on that day. This company supplies about three-fourths of London with gas, several smaller companies looking after the remaiuing fourth.

John Van Wormer, the regular candidate for secretary of the Union League Club, is one of the most popular gentlemen in New York. He has charge of the safe deposit and storage departments of the Lincoln Bank, and is General James' right bower. He comes from interior New York State, and years ago was one of the best telegraph operators in the country, Walter P. Phillips barred. He had charge of the night telegraph office in Albany for some years, and through reading the dispatches to the New York newspapers became proficient in State politics. For a time he served Senator Roscoe Conkling as private secretary in Washington, and thus he became proficient in National politics.

A recent issue of *Judge* had on its first page a colored cartoon representing President Harrison seated at a long distance telephone and speaking as follows: "Hello? * * * * is that you, Blaine? * * Happy New Year, Jim. * * Do you say that you will *not* take the Republican nomination? * * * Speak louder. * * LOUDER! * * * Oh, dear! You *must* speak more distinctly. I cannot make out what you say."

An amusing episode occurred on the electric railway on Thursday. An old lady hailed a car at a crossing and told the conductor she wanted to cure her rheumatism by having an electric ride.

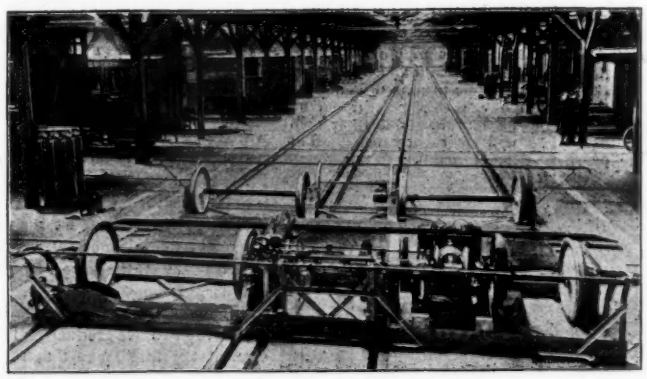
She got on board, sat down and proceeded a block. She then stopped the car declaring she was cured and expressed her gratitude to the conductor as she left the car.—*Ottawa Free Press.*

Electric Plant in the Railroad Depot at Stuttgart.

The electric plant for illuminating the railroad depot at Stuttgart was completed in November, 1889, by the firm of Erlinger & Sons. The dynamo and engine room contain three compound engines of 35 to 45 horse-power each, and three boilers, each having a capacity of 39 square metres (400 square feet) heating surface. Two are daily in use and one in reserve. The engines work at a pressure of eight atmospheres and have speed of 150 revolutions, and drive, by belting from a countershaft, four arc light dynamos of 120 horse-power each and two incandescent dynamos of 125 horse-power. They are all self-regulating from 105 to 110 volts.

There are in operation 203 incandescent lamps of 16 candle-power and 20 lamps of 35 candle-power, obtaining their power from the two incandescent dynamos connected in parallel (each having a capacity of 7,700 watts). A six horse-power motor is attached to a platform, on which cars are placed to shift or transfer them to their different sections in that part of the depot intended for their storage.

The adjoined photo-engraving represents the car-house referred to, containing room for more than 100 cars; in the foreground is the movable platform, consisting of two parts, the nearest containing the electro-motor of six horse power, seen at the right side attached directly to the common axis of the four wheels running on the double track; next to two of the rails deep grooves are seen, on the bottom of which the conducting copper rail is placed, and thus out of reach of any accidental contacts, while from there the current is conducted by brushes to the motor by switches which the operator, standing at the left of the motor, has within his reach and cause the platform to move forward or backward. Just behind the motor the platform proper is seen, with its rails, on which rails the car to be shifted is placed, while beyond this platform the form of other wheels are seen, making eight wheels supported by the whole platform with car and motor.



ELECTRICAL TRANSFER TABLE AT STUTTGART, GERMANY.

It has been found that six horse-power is amply sufficient to transfer the heaviest freight cars fully loaded, which, of course, is largely due to the care bestowed in having all the rails on a perfectly dead level.

Another electric plant in Stuttgart has been placed in the establishment of the United German Publishing Company. It was installed a year ago in connection with two steam engines of 60–70 horse-power each, operating two shunt dynamos by belt transmission. The dynamos have a capacity of 600 amperes at 107 volts, with a speed of 400 revolutions. The lighting installation is 850 incandescent and four arc lamps.

There are also two accumulator plants connected with this establishment, one for lighting purposes and one for use in electro-plating. These accumulators consist of 53 cells of the Tudor type, furnished by Mueller & Einbeck, of Hagen, in Westphalia, now known as the Accumulatoren Actien Gesellschaft. These cells have a capacity of 224 ampere hours.

Prize for a Primary Battery.

The Italian technical journal, *Elettricita*, of Milan, offers a prize of 2,000 francs for a new practical simple primary battery for industrial use. The competition will remain open from January 1 to August 31, 1892, open to all senders. The jury will be composed of responsible and competent persons.

Big Flour Mills to be Run by Electricity.

The immense flour mills now being erected at St. Louis, on West Third street, will be operated by electricity alone.

This is a decidedly new departure in the flour mill industry and it is stated that should it prove satisfactory, all the mammoth mills of St. Paul and Minneapolis, including those of the Pillsbury English syndicate, will introduce electricity for motive power. A power station will be erected at the Falls of St. Anthony for generating the current.

Electric Welding of Iron Wheels.

Electric welding is now applied to the work of manufacturing iron wheels. The process of welding the hub, spokes and tire of a wheel is accomplished in 30 seconds. First the tire is laid on the machine, then half of the hub, which contains notches in which the spokes fit. The latter are laid in the hub and inserted in the tire, and then the other half of the hub is laid on top of the lower half. These are held together by hydraulic pressure. The electricity is turned on, the iron becomes heated to the proper degree and welds.

The pressure is removed, the now compact wheel taken from its resting place, rolled aside and allowed to cool. The work is done in very much less time than it took by the old process.

The Proposed Cable to Honolulu.

The soundings recently completed by the "Albatross" are probably more favorable to the project of laying a submarine cable than the previous set, obtained 17 years ago by by the U. S. S. "Tuscarora."

No prolonged plateau was found like that of the Atlantic, but, taken as a whole, the results show a much more favorable location than that run by the "Tuscarora."

The most favorable landing place indicated seems to be Monterey Bay, a little south of San Francisco, and at the other end the best landing was only a few miles from Honolulu.

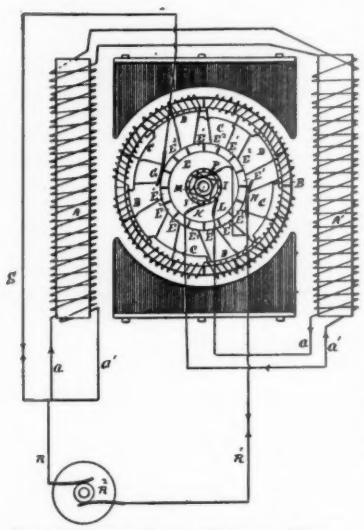
Of course, the work done by the "Tuscarora" and "Albatross" is only preliminary to that which would have to be undertaken should a commercial company take up the enterprise, but it would prove of great assistance in indicating a feasible route for additional soundings.

A cable to Honolulu would naturally contemplate ultimate extension to New Zealand and Australia or to China and Japan.

PROGRESSIVE ELECTRICAL INVENTIONS.

ALTERNATING CURRENT MOTOR.

In the accompanying engraving is illustrated the latest contribution to the art of alternating current motors, the same being the invention of Thomas H. Hicks, of Detroit, for which a patent was granted December 29. The machine is of the synchronous type, and is provided with two independent field magnet and armature circuits, through which the successive reversals of the alternating current are directed by commutators, so that successive impulses will traverse oppositely wound coils, thus developing the magnetism of continuous polarity in the field magnet and armature. In the diagram, R^2 represents an alternating current generator and R and R^1 the mains. A and A^1 represent the field magnet windings, which comprise on each limb of the field magnet two oppositely wound coils, connected with



HICKS' ALTERNATING CURRENT MOTOR.

the main circuit on one side and on the other side with two brushes, K L, bearing upon a selecting device which throws the circuits alternately into operation. The brush P constitutes a common return for the two circuits. The armature represented is a Gramme ring, upon which are two independent oppositely wound sets of coils connected to alternate blocks of a commutator. The armature circuit is in shunt relation to the field magnet circuits. When thrown into action, the machine starts under no load and gradually rises to a synchronous speed, after which the commutator for the armature successively directs the current impulses to the oppositely wound armature coils and thus developes a continuous polarity. Simultaneously the impulses carried through the field circuits are directed by the distributing brushes, K L, to one or the other field magnet circuit and thus a continuity of polarity is preserved in the field magnets. This machine will, of course, have the difficulties common to all synchronous motors—of falling out of step on overload and, while out of step, operating at low efficiency.

ELECTRICALLY PURIFYING OIL.

In the accompanying engraving is illustrated an apparatus for purifying oil containing metallic substances, and especially oil that has been used for lubricating machinery. The principle upon which the invention acts is electrolytic attraction, conducting particles following the current toward the anode of an electrolytic cell, and thus freeing the oil from contamination. In the apparatus illustrated is shown a tank containing water, in the bottom of which is an induction pipe H' through which the oil to be purified is fed. Drops of oil exude from the small tubes *h* and rise through the water by reason of their less specific gravity. A battery or other source of current, as shown at E, discharges through anodes supported near the top of the apparatus toward a cathode, preferably a cone shaped metallic bottom, as shown at C. During the transit of the particles of oil the foreign metallic particles are drawn by the current toward the bottom of the apparatus, being assisted by gravity, while the oil rises to the top, whence it may be withdrawn in the purified state. This invention has been recently patented by Mr. J. J. Lowden, of Everett, Mass.

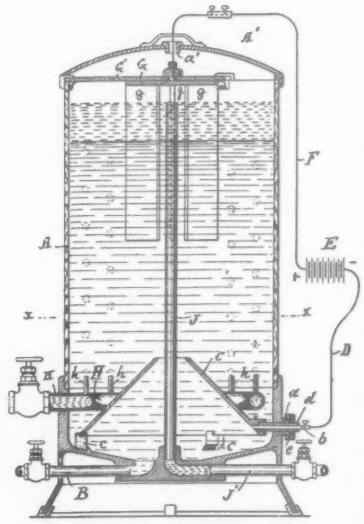
ELECTRIC RAILWAY TROLLEY.

A recent improvement in trolleys, the invention of Frank J. Sprague and P. F. O'Shaughnessy, of New York, is shown in the accompanying engraving. The trolley rod is mounted upon a frame operated by two springs, one of which, M, controls lateral movement, and the other of which, I, holds the trolley wheel in a vertical position against the conducting wire. This spring I is held normally in a state of tension by means of pins K K^1, which bear against opposite sides of a fixed bar A, which is fastened to the top of the car. The tension of spring I may be varied by changing the pins K K^1 to different holes, B, in collars mounted on a core. The trolley bar is supported by links L pivotally connected to a rocking frame G, at either side of which projects one of the pins K K^1, so that when the trolley is bent to either side this frame comes into engagement with one of the pins and is held against the conducting wire by the tension of the spring I.

Another improvement in trolleys has been recently patented by Charles S. Foster, of Whitesborough, N. Y., as shown in the engraving. Its principal feature is to keep the trolley wheel from jumping out of contact with the conductor. The trolley wheel is mounted in a yoke, the sides of which are inclined and provided with grooves in which slide two spring pressed wheels, C C, forming a closed arch over the conducting wire when the trolley is in position. A fork, E, and a cord connected therewith serves to pull the two wheels, C C, apart and permit the trolley to be lowered from contact with the conducting wire.

Last of the Poles.

Mayor Grant held a conference last week with representatives of the electric light companies in reference to the order of the Board of Electrical Control that all poles and wires should be removed within 90 days after October 12 last. Tuesday of this week was the last day of grace under this order. The electric light people promised the mayor that they would have all the poles down by the middle of the month, and at their own expense. This will clear away nearly all of the overhead wires remaining in the downtown district.



ELECTRICALLY PURIFYING OIL.

Brooklyn's Proposed Electric Railroad.

The State Railroad Commissioners, Wm. E. Rodgers, Isaac V. Baker and Michael Rickard, met in the Common council chamber at Brooklyn on the 7th inst., to hear the application of the Brooklyn street railroad companies for permission to substitute electricity for horses as the motive power.

The roads were well represented and several protestants appeared. The commissioners listened to arguments *pro* and *con* but made no decision.

They will meet again on the 18th inst., at Albany.

PRACTICAL NOTES ON THE REFLECTING GALVANOMETER AND ITS ACCESSORIES.

BY J. D. BISHOP.

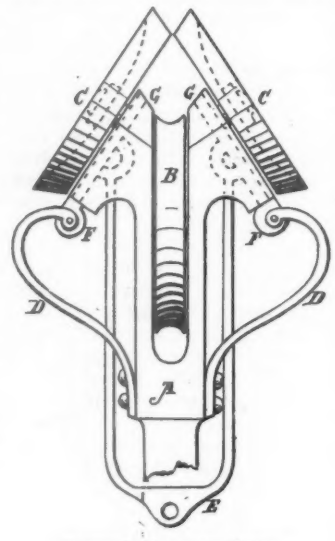
X.

FINAL ADJUSTMENT.

Lamp, scale and lens being adjusted and a steady bright spot secured, proceed to a final adjustment by centering your spot.

Light up your lamp. If your spot does not fall on the center zero of scale it must be made to do so.

First see that the center zero is exactly on the axial line of the coils and that the lamp



FOSTER'S TROLLEY GUIDE.

slot is also, so that mirror, lens, spot and center zero are all in line with each other. This being so, move the controlling magnet very gently until the edge of the spot falls on center zero.

Now take another bar magnet and place it parallel with, about two feet from, and with its poles in reversed position to that of the magnet already laid down and marked. Call this the adjusting magnet.

This will throw your spot off zero again, but a little intelligent moving of the second or adjusting magnet backwards or forwards will soon bring it back. The second magnet will be found available for two purposes. First, to determine the constant. That this is so is evident from the fact that, by moving it towards the first magnet, we reduce its influence on the galvanometer because we stultify its effect on the mirror by presenting to it an exactly opposite polarity.

Vice versa, by increasing the distance between the two, we gradually allow the influence of the first magnet to reassert itself. The constant may therefore be increased by approaching the second to the first magnet, lowered by withdrawing it. Secondly, it serves to adjust the spot to zero. This is done by shifting it a little longitudinally across the axial line, by which means the spot may be brought exactly to the center or the left hand zero, as required.

But it is a great inconvenience to be compelled to leave your seat every time you want to alter your constant or adjust your spot.

Of course, the latter may easily be done by shifting the scale a little, but it is not well to do this to so great an extent as would be required in shifting from one zero to the other when occasion requires. The finest adjustment may be secured by providing a long strip of thin pine with an expanded head like a baker's "peel," on which is placed the second magnet, whilst the handle extends beneath the board of the scale and overhangs the table a little so as to be easily controlled.

About two-thirds of its length from the handle end drive two small nails into the table, one on each side, leaving about one-eighth of an inch clear on each side. Drive a couple of drawing pins in the bottom of the head of the "peel" underneath the magnet so as to allow it to slide freely over the table.

By a slight motion of the end of the "peel" either backwards or forwards or sideways, using the nails as fulcrums, the spot may be easily and most minutely adjusted to either zero. Now connect up one cell, key galvanometer (see galvanometer leads) and resistance coils all open, on short circuit, put in 1,000 shunt. Adjust your spot to center zero. Depress your key and note the deflection and its direction. Reverse your battery wires and take another deflection which will, of course, be in the opposite direction.

The two deflections will be the same. Now experiment with your shunts and resistance coils with this one cell until you become perfectly familiarized with their general working.

Experimenting, also, on the effect withdrawing and approaching the second magnet will have on your deflections and, also, to what extent movement of the "peel" to the right or left is necessary to adjust your zero or place it where you want it.

Take a deflection with the lowest shunt you can use, starting from end zero, without the spot going off the scale and note it.

Now shift the second magnet at random and work at its adjustment until you get precisely the same deflection.

When you are at length perfectly able to understand the cause and effect of all you can do with one cell, it will do you good to dismount the whole paraphernalia and set it up again.

If you can then produce the same deflections as before, or any other deflection you may desire, you may consider yourself ready for taking a plunge into actual work, to do which invoke the assistance of Kemp, Culley or any other text-books.

But you will meet with many unlooked for results, or absence of all result before you are quite *au fait*. But there is always a good cause for either, although sometimes very difficult to find.

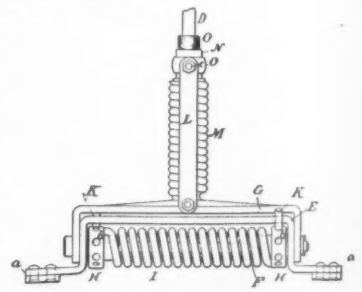
Galvanometers often display some wonderful "conjuring tricks," but they can all be discovered and prevented, and "when you know how, it is very simple."

"To know how" requires thoughtful intelligence, patience and experiment. But it is only by continual work that you will ever obtain that absolute confidence which alone makes galvanometer work the most interesting and encouraging in the whole domain of electrical science.

XI.

SHUNTS.

Galvanometers are invariably provided with a set of 10, 100 and 1,000 shunts, giving a proportionate value to the deflections. These proportions are only chosen for convenience in calculation, but sometimes it may happen that they are above or below your requirements, in which case your bridge resistance coils may be used as shunts, but, unless your bridge set is a good one, the results will not be so accurate, on account of the inferior exactness of the coils themselves and the number of the contacts required. It is better to make a few shunts yourself. Work out the resistance required for the shunt you need and measure it off as near as possible by the bridge, on a length of thick silk covered copper wire which may be then doubled in two, and, beginning with the doubled end, wound round a common sewing thread reel, finally fastened with a few turns of silk thread, leaving out a few inches of the two ends. Put it in place of the shunt and if you get less deflection than you require unreel a foot or so and carefully stretch the wire by a steady pull. This will reduce its diameter and also increase its length, thus increasing its resistance and causing more current to flow through the galvanometer.



SPRAGUE'S IMPROVED TROLLEY.

If your deflection is beyond the proportion you desire, your resistance is too great and it must be reduced by cutting off from the ends. If this is carefully done a little at a time you will have no difficulty in making any shunt you wish.

At any rate it will be good practice and you will find it very interesting work. German silver is better than copper wire, but for a beginner copper wire is easier to work with, because its resistance being so much lower, longer lengths may be cut off or stretched to effect the necessary adjustment. When you have made a few copper wire shunts you may begin on the more delicate adjustment of German silver shunts.

The approximate lengths of either wire you may require may be got from any of the tables of resistances.

When adjusted, the wire may all be coiled

on the reel, except a few inches, with which make a small spiral; wrap the reel round with a few turns of cartridge paper, on which mark its value as a shunt and leave end of the spiral standing out for connection across the ordinary shunt terminals. The silk may be kept from getting loose and untwisting by gumming or tying it.

It is needless to say that when using these shunts the peg must be out of the regular shunt box. The object of doubling the wire is to prevent a "kick" on the spot, which might arise from self-induction in the coils when the current passes or ceases.

In many cases, especially when making experiments, where the proportionate value of the shunt is of no consequence, but where it is only required to confine the spot to within the scale, the bridge set will be found very useful as a shunt; but if the lowest of these coils is too high, remove the bridge and put in across the shunt terminals a length of stout bare copper wire longer than necessary, which cut in two in the middle and then make contact by sliding them one on another towards the shunt box, or from it, until the deflection you require is obtained, then twist them together and cut off the ends.

This is a rough and ready, but quick and efficient way of making an arbitrary shunt.

The correctness of shunts may be easily checked by a comparison of the deflections they give with the deflection when no shunt is used. This should be done from time to time as a matter of duty.

When a shunt indicates higher than it should, look for a dirty peg or a weak contact between it and the terminal blocks it joins together. Clean both well with clean chamois leather and replace the peg with a twisting motion.

If it indicates lower than it should, remove the case and examine the coils to see if the silk has not been burnt off by an excess of current, thus allowing the coils to come into contact. This does sometimes happen and is very troublesome.

For any kind of a fault, however, first try a good cleaning with a dry chamois, between the terminal blocks especially, as dust always accumulates there. Damp condensing on the hard rubber is a fruitful source of annoyance.

Terre Haute Electric Club.

A New Electric Club has been organized at Terre Haute, Ind. The following officers were elected: President, Robert Moore; vice-president, John Davis; secretary, William Bledsoe; treasurer, W. H. Schaffer.

Contracts to Let.

Eugene T. Lynch, Jr., consulting electrical engineer, 120 Broadway, New York, is prepared to receive bids for wiring several large buildings in this city and is ready to hear from companies or individuals in the market for such work.

New York Electric Club.

The Next Entertainment at the Club will occur toward the end of the present month. Mr. Herman Hollerith, of Washington, will read an address and show in practical operation the Hollerith electrical counting machine as used in the last census.

American Institute of Electrical Engineers.

The Sixty-third Meeting of the American Institute of Electrical Engineers will be held at 12 West Thirty-first street, New York, Tuesday evening, January 19. A paper will be read by Mr. Chas. P. Steinmetz, of Yonkers, N. Y., on the "Law of Hysteresis." Advance copies of the paper are in preparation and will be forwarded to such members as desire them.

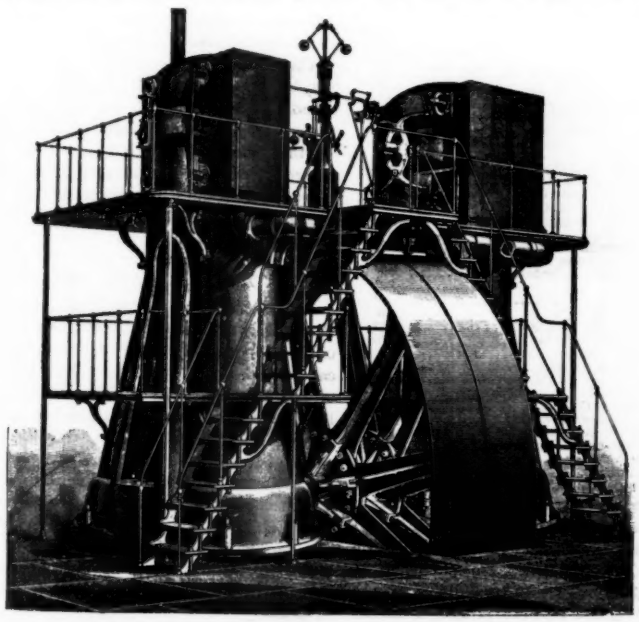
The Edison Electric Light Company's Dividend.

A temporary injunction was obtained on the 4th inst., by Martin A. Frank, from Justice Andrews, of the supreme court of New York, restraining the Edison Electric Light Company and the Edison General Electric Company from declaring a dividend of 80 per cent., payable in collateral trust debentures of the Edison Electric Light Company. Frank, some time ago, sued these companies, objecting to the absorption of the Edison companies by the Edison General Electric Company; that suit is still pending, and this motion for an injunction is made in it.

Helena, Mont.—Helena Rapid Transit Company; capital, $500,000. Promoters, J. H. Lawrence, W. H. Clark, A. Barboro, all of Helena.

Vertical Corliss Engines for the New Electric Railway Station, at Newark, N. J.

The accompanying illustration, for which we are indebted to *Power*, is descriptive of a vertical engine of new design, several of which are being built by the Corliss Steam Engine Company, of Providence, R. I., for the new electric railway station at Newark, N. J. The general features of the design are apparent from the engraving. The engines are cross compounds, with cylinders 18 and 36 inches in diameter and 36 inches stroke, and are designed to run 90 revolutions per minute, with an initial pressure of 125 pounds, under which conditions they are rated at 400 horse-power each. The main shaft is 13 inches in its greatest diameter, and 11.8 inches in the bearings, the length of which is 26 inches each. This shaft carries the cranks at its ends, the low pressure crank leading the other by one-quarter of a revolution. At the center of the main shaft are two belt pulleys 18 feet 2 inches in diameter, with faces 30 inches in width, each pulley to carry a 28-inch belt. The wheels are built up in segments in the manner ordinarily followed by these shops, and weigh complete about 35,000 pounds each. The outside dimensions are: Length, 24 feet; width to stairways, but not including flywheels, 15 feet; height to top of low pressure cylinder, 12 feet 8⅓ inches. At its rated load of 400 horse-power, the engine will furnish one horse-power for each .9 of a foot of floor space, but at its maximum power, which is 600, will require only .6 of a foot per horse-power. Steam is supplied to the high pressure cylinder by a 6-inch pipe, and exhausted into a 10-inch pipe, which forms the receiver between the two cylinders, giving a volume about four times the capacity of the high pressure cylinder. The final exhaust pipe to the condenser is 12 inches in diameter. Independent condensers will be used, but the type is not yet decided upon. In connection with these engines there will be used 12 Corliss vertical boilers, each 84 inches in diameter, with 2,010 square feet of heating surface and 33 square feet of grate surface. Each has 229 tubes 2¼ inches in diameter and 14 feet long.

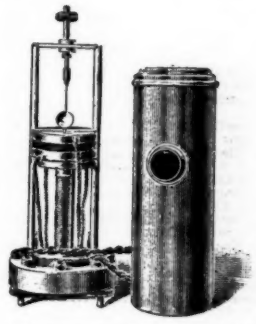


VERTICAL CORLISS ENGINE AT THE NEW ELECTRIC RAILWAY STATION, AT NEWARK, N. J.

Six of the engines described will be belted direct to two 200,000-watt generators, the ultimate capacity of the station being 4,000 horse-power. It is proposed to furnish power for over 80 miles of street railway operated by the Newark Passenger Railway Company. The objective features in the design of the plant we have illustrated and described here have been to get, as nearly as possible, the largest amount of power on the smallest amount of real estate with a building not more than one story in height, and to obtain the economical efficiency of the Corliss type of engine without the intervention of countershafting. Careful attention has been paid to facilities for handling the work. Traveling cranes are furnished above both engines and generators, and the coal is landed at the dock upon a trestle and conveyed to an elevated storage, whence it may be delivered by chutes directly to the boilers. The work is being done under the supervision of the Field Engineering Company, of New York.

A New Form of Electric Measuring Instrument.

The accompanying illustration shows an electrostatic instrument recently brought out by Messrs. Swinburne & Company for experimental work in connection with alternate currents. Instead of quadrants there are two pair of half disks so that the angle



NEW ELECTRICAL MEASURING INSTRUMENT.

of deflection can be large. The needle consists of two half disks fastened on a metallic arbor. It is held by top and bottom suspensions. One disk is in the upper box and the other in the lower. The boxes are connected, not to ordinary terminals, but to highly insulated flexibles, as the ordinary terminals are not suitable for high pressures. This instrument can be used as a voltmeter, or it may be connected up to measure power by any of the various methods involving two readings. It can also be connected up as a direct reading wattmeter. The electromagnet below the boxes acts on a copper drum and renders the instrument dead beat. This magnet is excided by a cell. For large readings the torsion head and pointer on the top of the instrument are used; but for small readings the mirror is employed. Four of these instruments have been lent to Dr. Fleming to carry out experiments on the measurement of power by various different methods.—*London Electrical Review.*

Terrebonne, Canada.—Terrebonne Electric Light Company; capital, $12,000. Incorporators. Hon. Louis R. Masson, R. H. Buchanan, E. S. Mathieu, C. Gauvreau, W. Joubert, A. Piche, M. Moody, L. H. Desjardins, A. H. Masson, Mathew Moody, A. Masson, C. Chapleau, Mrs. C. Archambault.

Watertown, Mass.—Watertown Machine and Electric Company.

Hartford, Conn.—Hart & Hegeman Manufacturing Company; capital, $21,000.

Canisteo, N. Y.—Canisteo Valley Electric Railroad Company; capital, $20,000. President, William T. Bailey.

Chicago, Ill.—The Illinois Electric Lamp Company; capital, $25,000. Incorporators, J. F. Schlefer, O. M. Smith and Frank E. Baker.

Breckenridge, Colo.—The Breckenridge Electric Company; capital, $20,000. Incorporators, Hal. Sayr, Irving Hale and Horace Hale.

Ottawa, Ill.—Ottawa, Starved Rock and Western Electric Railway and Power Company; capital, $150,000. Ferdinand Walther, president.

Jamaica, L. I.—The Ozone Park Electric Light and Power Company; capital, $2,000. Trustees, John N. Williamson, Henry C. Rath, David B. Emmons.

Chicago, Ill.—The Jewel Incandescent Lamp Company; capital, $20,000. Incorporators, William Lopland, Olf Wernberg and John A. Westerlund.

Fresno, Cal.—Fresno Street Railway Company; capital, $1,000,000. Officers, Marcus Pollasky, president; J. R. White, treasurer; Maurice Messinger, secretary.

Mifflin, Pa.—The Duquesne Heat, Light and Power Company; capital, $20,000. Directors, C. F. Keyser, J. F. Black, J. R. Wylie, H. L. Black and J. G. Neverhire.

Apollo, Pa.—The Apollo Electric Light, Heat and Power Company. Incorporators, Geo. G. Martin, J. J. Vandergrift, W. B. Rhodes, T. H. Vandergrift and Wallace P. Bache.

Newville, Pa.—Newville Electric Light, Heat and Power Company; capital, $5,000. Directors, W. G. Stewart, E. F. Bloser, Stacey G. Glauser and Joseph H. Woodburn.

Breckenridge, Colo.—The Breckenridge Electric Company filed a certificate of incorporation yesterday with the Secretary of State. Directors, H. M. Hale, Hal. Sayr and Irving Hale.

Baltimore, Md.—The Maryland Electric Light and Power Company; capital, $50,000. Incorporators, Wm. J. Dickey, Oregon R. Benson, Stephen J. Van Lill, Wm. H. Harken and Charles W. Dorsey.

Fredonia, N. Y.—Fredonia Electric Light, Heat and Power Company. Directors, Hon. George Barker, president; L. McKinstry, secretary; F. R. Green, treasurer; B. F. Skinner and John A. Warren.

Baltimore, Md.—The S. D. Warfield Company; capital, $100,000. Incorporators, S. D. Warfield, Calvin S. Shriver, C. T. Jenkins, Geo. Cator, J. C. Gittings, R. E. Warfield, E. W. Phillips and A. W. Smith.

Sault Ste. Marie, Mich.—Edison Sault Electric Company; capital, $57,000. Promoters, Harris T. Dunbar, Wm. Chandler, Minnie C. Dunbar. Incorporation papers sent to H. W. Oren, Sault Ste. Marie, Mich.

Grand Rapids, Mich.—The Grand Rapids Water, Power and Boom Company; capital, $50,000. Promoters, J. R. Hawes, Brainard J. Grant, C. A. Long. Incorporation papers sent to W. A. Barr, 328 Robert street, St. Paul, Minn.

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Two more murderers, McElvaine and Trezza, have been sentenced to be electrocuted on February 8. At the request of the Italian Government, Governor Flower has granted Trezza a reprieve pending a further investigation of his case.

The application of electricity to mining is increasing very rapidly, and it is safe to predict that it will become general in the near future. Very frequently mines are situated but short distances from water powers, and the transmission of current becomes a very simple matter. The saving in cost of operation over that where coal is used is simply enormous. Many mines which it has heretofore been impossible to work, owing to the cost of coal and its transportation, are now, by applying electricity for motor power and other purposes, operated and operated at very satisfactory profit. The increase in value of these properties will add a very considerable sum to the aggregate wealth of the country.

A murderer in Pennsylvania begs to be burned at the stake. If he really wanted to die a horrible death he should have committed his crime in New York State.

We are pleased to learn that the telegraphers of the Southern Pacific Railroad have settled their grievances with the railroad company by an agreement acceptable alike to both parties.

The addresses which will be read before the Buffalo convention of the National Electric Light Association will be interesting, practical and comprehensive. It is understood that the programme has been arranged to cover every detail of work, from the coal pile to the dividend.

There is, perhaps, no more striking illustration of the progress of humanity, as well in the cardinal virtues as in knowledge, than is offered in the biography of Priestley, found elsewhere in this paper. We see there that in conservative England a statue was unveiled on the very same spot where 100 years before the man to whose honor it was erected had to flee for his life in order to escape the persecution of his fellow men, animated by bigotry and intolerance. They were the ancestors of the men who now honored him, because they have reached a higher platform of civilization and enlightenment, of which the cardinal virtues are appreciation of progress and tolerance towards all.

REPEAL THE WHOLE LAW!

Governor Flower's recommendation to the New York State Legislature, advising a repeal of that feature of the electrical execution act which prohibits the newspaper publication of an account of the details of the execution, simply voices the popular sentiment regarding this most unwise and un-American action by the legislature.

How such a clause could have been passed in this century of free and liberal ideas is beyond comprehension, and we might go further at this time and express our deep conviction that the entire act is a mistake, not to use a stronger word, as it will doubtless be proven when the light of day is thrown upon the inhuman details of this most unnatural mode of taking the lives of criminals.

The action of the legislature will, we doubt not, be in accord with the governor's recommendation, and we shall hail the repeal of the *press-gag* clause with much pleasure, feeling that, when the revolting facts are placed before the public, the law in its entirety will be swept from the statute books of the State as a disgrace to civilization. Let the legislature now do its duty.

THE TROLLEY IN BROOKLYN.

A legal point now arises regarding the veto of Mayor Boody of the aldermanic resolution adopting the trolley system of street car propulsion in Brooklyn. The counsel of the Brooklyn City Railroad Company most emphatically state that, owing to the failure of Mayor Chapin, the retiring official, to act upon the resolution prior to the expiration of his term of office, December 31, it has become a law. The large majority by which the act was adopted by the board of aldermen would also indicate their entire ability to pass it over the Mayor's veto. Whether such action will be taken remains to be seen.

The matter, it is plain, has not been settled by the veto of Mayor Boody, and it seems altogether probable that the trolley will be in use in Brooklyn before the year is out.

The objections of the present mayor are very ancient, and have long ago been disproved by actual results in Boston and elsewhere.

From all we can learn of the general feeling towards the new form of motive power for the Brooklyn street cars, the opposition cannot sustain itself against the popular verdict in its favor, for the adoption of the use of electricity will not fail to greatly increase the value of property in the newer portions of the city and a very decided growth in its population, as a result of the overflow which would surely come from New York.

IS THE ROTARY FIELD CONSTANT OR VARIABLE?

The very interesting discussion of rotary current generators and motors which followed the reading of Professor Pupin's paper on "Polyphasal Generators," before the American Institute of Electrical Engineers, is presented on another page. So far as concerns the question of fluctuation of magnetic strength of poles during rotation, the discussion, although somewhat profuse, leaves the result in deep shadow. Mr. Steinmetz maintains that there is no fluctuation, but that the rotating field is of constant strength, and attempts to fortify his position by applying the parallelogram of forces, assuming that the field strength will be accurately represented by the resultant of two right angle components formed by the sine and cosine of the phase angle. The accuracy of the premises seems to be open to very grave doubt. Assuming that the current waves have, like the wave of electromotive force, a true sine variation, the number of lines of forces resulting at any instant from each of two coils in Ferraris' arrangement, would be strictly proportional to the sine and cosine of the phase angle and the whole number of lines developed would be represented by the sum of the two currents, and would be proportional to the *sum* of the sine and cosine. The parallelogram of forces has no application, for the reason that the two forces do not act at right angles, but when an annular iron core is used, act at 180 degrees; but they do not, as in two opposed mechanical forces, neutralize each other, but produce a consequent pole of double strength, that is to say, a pole which represents the sum of all the lines of force finding origin in both coils. Assuming that no iron path is provided to lead the lines of force into direct opposition, the field would be only more widely diffused, but the principle would be the same, wherever two opposing lines of force met they would simply unite in multiple arc. The number of lines due to the two coils at any instant is proportional to sine plus cosine of the phase angle, and since the sum of the sine and cosine is not a constant for all angles between 0 and 90 degrees, it is not clear how the field strength can be a constant. The position of the poles changes with the sine of the phase angle and the lines of force of both coils at any instant unite in multiple arc at that point and flow over a return path to the opposite pole. The case is analogous to two opposed batteries; a wire bridging the opposite poles will unite them in multiple arc. The test suggested by Professor Thomson ought to show practically whether the field fluctuates. If a core be provided with two oppositely wound superposed coils, and two currents a quarter phase apart be sent through the coils, only the number of lines of force representing the excess of one effort over the other at any instant would polarize the core, and a coil placed over the end of this core would carry induced currents if there existed any fluctuation of magnetism. By superposing the coils the locus of the poles could be fixed; so that the magnetic condition could be more readily explored.

If the strength of field be truly represented by the sum of the magneto-motive forces at any instant, Dobrowolsky's reasoning, that the greater the number of phases used the less will be the fluctuation in field strength, seems impregnable.

Concerning the character of the magnetic circuit, it is not clear why the principle should differ in circuits containing all iron or part iron and part air. If the magnetic circuit be truly amenable to Ohm's law, the strength of field must be affected only by magneto-motive force and magnetic resistance. In the case of a simple iron armature the resistance would be constant under the same load; in a closed coil armature a counter-magneto-motive force would be developed which would be a function of the fluctuating field. In either case the magnetic field could not be maintained constant; in the latter case the armature fluctuation would lag behind that of the field, and increase it at one time as much as it would reduce it at another.

Looking at the subject from another point of view, it would seem that just as an increase of the number of commutator segments in a direct current generator will increase the smoothness of the current, so will an increase of the number of phases in a polyphase motor result in a smoother field.

CORRESPONDENCE.

OUR LONDON LETTER.

Belfast.—An underground electric railway, similar to those proposed in London, is now being mooted for Belfast.

Brighton.—Volk's Electric Railway Line, which was so severely damaged in the late gales, has now been thoroughly restored, and the cars have resumed working.

The Krasnapolsky Winter Garden.—This splendidly decorated building, in Oxford street, has been lighted throughout by electricity. There are four arc lamps and over 1,500 incandescent. For generating plant there are three of Ruston, Proctor & Company's compound engines, driving three Crampton compound wound dynamos, each capable of supplying 380 amperes at 110 volts. The installation has been carried out under the direction of Mr. G. E. M. Hartmans, consulting engineer.

Electric Lighting of the Mansion House.—The Planet Electric Lighting Company have, after five weeks' work, at last completed the electric lighting installation at the Mansion House. The committee appointed by the corporation have visited the building, and express their thorough satisfaction with the manner in which the work has been carried out. This is the first time the electric light has been used in the official residence of the lord mayor, and the various reception and state apartments appear to very great advantage.

Messrs. Laing, Wharton and Down's Fire.—The serious fire at the company's works in New Bond street has in no way interfered with the carrying out of orders. The damage was estimated at £8,000, and unfortunately the premises were not insured to the full value, and there was also a large further loss in electroliers and candelabra left with the firm for repair or alteration. The works are, of course, to be rebuilt. Messrs. Laing, Wharton and Down offer their best thanks to other electrical firms for kindly offers of help, and state, as a curious fact, that the advertisement given by the fire caused a large increase in orders.

The Institution of Electrical Engineers.—The annual general meeting was held on the 11th inst., and the following were elected as members of the council for 1892: President, Prof. W. E. Ayrton, F. R. S., President Physical Society; vice-presidents, Alexander Siemens, R. E. Crompton, M. Inst. C. E., Sir David Salomons, Bart., M. A., Sir Henry Mance, C. T. E., M. Inst. C. E. New members of council in addition to those remaining in office, Edward Hopkinson, M. A., D. Sc., M. Inst. C. E.; Professor John Perry, D. Sc., F. R. S.; Prof. A. B. W. Kennedy, F. R. S., M. Inst. C. E.; and James Swinburne. Associate members of the council, Captain L. A. Beaumont, R. N.; M. Cooper and Capt. W. C. Hussey, R. E. The Paris Electrical Premium has been awarded to Mr. J. Swinburne, for his paper on transformer distribution. Mr. F. H. Webb, the secretary, after reading the annual report announced that Professor Nikola Tesla is on his way to England and had promised to lecture before the Institution in January next on his high frequency experiments, and that no pains would be spared by the council that the lecture should be properly and completely experimentally illustrated.

London Electric Underground Railways.—Four new schemes for underground railways to be worked by electricity will be before the next session of Parliament. One, Great Northern and City Electric Railway, from Finsbury Park to Finsbury Pavement; the Waterloo and City Electric Railway, from Waterloo station to the Mansion House; a third from New street, upper Baker street, passing Piccadilly Circus to Waterloo; and the City and South London made application for an extension from City Road to Islington. In regard to the latter, Mr. Mott's scheme last year proposed no actual junction with the existing railway in the city, but to have a subway for foot passengers connecting the two sections. The committee, under the presidency of Mr. Hanburg, rejected the scheme, but the material amendments which have been made remove many of the objections put forward by the opponents of the bill last session. The Central London Railway Company have stated their intention to apply for an extension of the line authorized last year to Liverpool street. The preliminary borings made by the Central London Electric Railway reveal satisfactory conditions. The strata are easily worked, and no very formidable water difficulties are apprehended.

As a Result of a Month's Tour through the leading towns of France, Germany, Italy and Switzerland, one is forced to the conclusion that here in England we are lamentably behind-hand in our use of the electric light as an illuminating power. In Rome, Florence, Milan, Turin, Genoa, Berlin, Cologne, Basle and Luzerne, not merely the leading thoroughfares, but every hotel and decent café is so lighted. At Monte Carlo, the first-class hotels all have an installation, and as for the Casino, it is one of the best lighted buildings in Europe. In Paris, also, great strides are being made, and the leading shops set London an example that must be followed if they would show off their goods to the best possible advantage. While on April 1, 1890, there were 22,000 electric lamps in Paris, on July 31 last, the number had increased to 64,000. For the lighting of the Champs Elysée, from the Place de la Concorde, to the Arc de Triomphe, a company is now about to commence work, and one of, if not the most famous avenues in Europe, will shortly be a blaze of arc lamps. I have also learned that a new electrical journal, *L'Industrie Electrique*, under the management of M. E. Hospitalier, will be published at the commencement of the new year. In Switzerland, between Valsthal and Langenthal, an electric railway is about to be started. In Germany, as an experiment, for the last month the night express between Frankfort and Berlin, has been lighted by electricity. Accumulators charged at the works in Gelnhausen supply current for the incandescent lamps. Each carriage has two lamps, one of which can be switched off by the passengers, while the other can only have the curtain drawn over to darken.

CHARLES FFRENCH.

London, December 30, 1891.

OUR CHICAGO LETTER.

The Electric Merchandise Company is having great success in the sale of their special brand of tape. Among the many recent orders received is one for 3,000 pounds to one party, which speaks well for the merit of this tape.

Ernest L. Clark has severed his connection with the Illinois Electric Material Company, Chicago, as secretary, and is now located at 331 Rookery, with the Ernest L. Clark Company, and would be pleased to hear from parties desiring prime white cedar poles for electric construction.

The Cicero and Proviso Electric Railway have been requested by the residents of Oak Park to reduce the speed of its cars running between Fortieth street and the Desplaines river on West Madison street, and on West Lake street to Oak Park, claiming that lives are endangered upon the streets at the speed they now run their cars. The company have granted their request and are putting in new motors in order to speed down all their cars.

The Electric Light Company which has secured the contract for lighting the town of Cicero for a period of five years has secured a location at the corner of Harrison street and Central avenue, on which it will erect a plant at once. From this location power will be furnished to light the streets of Oak Park, Austin, the Grant Locomotive Works, Clyde, Hawthorne and other populous districts of Cicero. Work is to be begun on the plant at once.

All the Thomson-Houston Electric Companies have combined to make a big display at the Fair. President H. A. Pevear and Vice-President C. A. Coffin say that $500,000 will be spent in making this exhibit. Not less than 20,000 square feet will be required for the display. The companies that have decided to unite for this exhibit are the Thomson-Houston Electric Company, the Thomson-Houston Motor Company, the International Electric Companies, the Thomson-Van Depoele Electric Mining Company and the Thomson Electric Welding Company.

The Western Electric Company has purchased the plant of Collins & Burgie, stove manufacturers, at 261 to 277 Clinton street, for $320,000. The ground fronts east on Clinton street, south on Congress and north on a 16-foot alley. It has a frontage of 193 feet on Clinton street and 318 feet on Congress street. It is occupied by a three-story brick building covering the entire frontage. The Western Electric Company has an extensive plant north of the alley, and it is presumed that the purchase was made with a view to future extensions of the company's growing business. The transfer was made by the heirs of James L. Collins and Henry C. Burgie to President E. M Barton, representing the electrical company. M. J. B.

Chicago, January 9.

OUR ALBANY LETTER.

The Handsome new exchange building of the Hudson River Telephone Company, at Albany, is nearing completion.

The Watervliet Turnpike Electric Railway has its immense snow-sweeper out to tackle the first genuine storm of the season. It attracts a deal of attention and does efficient work.

At the Opening Session of the New York State Legislature, on Tuesday, Assemblyman Stein introduced a bill that six newspaper reporters be admitted to electrocutions occurring in this State.

The Telephone Company at Troy, N. Y., has asked the common council for a franchise permitting the company to place its wires underground throughout the city. The cost to the company will be at least $75,000. The proposition will be further considered.

The Telephone Company at Cortland, N. Y., has been obliged to increase its rates to new subscribers on account of the project to rebuild its lines. Mr. Bickford has received orders to make a map of the lines as they are now and to make estimates on the expense of rebuilding the entire plant. The Central Exchange will also probably be fitted with the latest appliances, so that subscribers requiring the metallic and long-distance instruments may have them. The Cortland service is controlled by the Empire State Telephone Company. L. M. W.

Albany, January 9.

OUR BOSTON LETTER.

The Pettingell-Andrews Company, of this city, has presented this office with its 1892 calendar, and which is, as usual, among the neatest and most serviceable publications of the kind.

The Annual Ball of the Telephone Employés' Mutual Benefit Association, of Massachusetts, will take place at Odd Fellows' Hall, this city, Thursday evening, January 21.

Mr. G. M. Haskell, of the Thomson-Houston Electric Company, who has been looking after the varied interests of his employers in San Salvador during the past nine months, has returned to this city.

The Boston Electric Club's inaugural dinner for the year 1892, to be held at the Parker House next Monday evening, will undoubtedly prove a successful event, as nearly 100 people have notified Secretary Ross of their intention to be present.

The American Electrical Works, Providence, R. I., again sends a pleasing little remembrance to all its friends. This time it is a handsome little package of 52 cards—one for each week in the year—neatly decorated in colors, and bearing the name and address of the sender. W. I. B.

Boston, January 9.

Against Electric Roads.

A despatch from Trenton, N. J., dated January 8, states that opinions have been filed by Judge Reed which defeat the project of constructing electric railroads in Newark and Trenton.

PERSONAL.

Mr. M. D. Law, of the Edison General Electric Company, Schenectady, N. Y., visited New York last week.

Mr. T. W. Sprague, of the Thomson-Van Depoele Electric Mining Company, Boston, was in New York last week.

Prof. J. P. Barrett, of Chicago, chief of the World's Fair department of electricity, was a metropolitan visitor a few days since.

Mr. W. L. Adams has been elected secretary and treasurer of the Electric Merchandise Company, Chicago, *vice* Mr. A. H. England, resigned.

Mr. H. K. Gilman, president of the Great Western Electrical Supply Company, Chicago, was in New York last week and made his headquarters at the Electric Club.

Mr. Charles R. Huntley, of Buffalo, president of the National Electric Light Association, was in the city last week conferring with Secretary George F. Porter on Association matters.

E. A. Van Wie has resigned as secretary-treasurer and general manager of the Rockford, Ill., Electric Manufacturing Company, and W. B. Roberts, late of Duluth, has been elected in his place.

W. Dwight Wiman, a son of Erastus Wiman, and general manager of the Richmond County Heat, Light and Power Company, at St. George, S.I., last week met with a painful accident. A fire occurred in the office of the plant, and Mr. Wiman, in attempting to break in the door of the office with an axe, cut himself on the left foot, inflicting an ugly wound. He was assisted to his house nearby, where he received medical attendance. The fire was extinguished before much damage was done.

Mr. Chas. R. Hosmer, general manager of the Canadian Pacific Railway Telegraph, and one of the vice-presidents of the Commercial Cable Company, better known as the Mackay-Bennett Company, was recently tendered a complimentary banquet at the St. James Club, Montreal, by his friends and admirers, who at the same time presented him with a magnificent solid silver service, valued at about $3,000. The compliment paid Mr. Hosmer was in appreciation of his valuable services in connection with the Commercial Cable Company, in which a great many Canadians are interested.

EMINENT ELECTRICIANS.

FACTS ABOUT FAMOUS MEN WHOSE NAMES WILL ADORN THE ELECTRICITY BUILDING AT THE WORLD'S FAIR.—BY DR. P. H. VAN DER WEYDE.

VII.

Joule—James Prescott (1818–1875); English physicist. Pupil of Dalton, the great reformer of the chemical theory. His first publication was on electro-magnetic motors. He continued Jacobi's experiments in electricity as a motive force, but soon arrived at the conclusion that zinc can not compete with coal as a motive power, because he calculated that it cost 25 times more to produce the same power with zinc in a battery than the cost of coal in a steam engine. Practical experience has since proved that this is by no means over estimated, but that the figure of 50 times the cost of coal is nearer to the truth, especially when we take in account the cost of the acid which must furnish the oxygen to the oxidizing zinc, while the atmospheric oxygen costs nothing. The inventive talent of Joule was also applied to the improvement of galvanometers. But his attentions were principally directed to the most important problem of heat in relation to mechanical power, and the determination by experiment that the descent of a weight can produce heat, and inversely that heat can raise a weight; that in the first case heat could be generated by the application of power, and in the second case power could be generated by the application of heat. He varied his experiments in the greatest possible diversity and obtained always mutually concurrent results. At last he established as a law (now generally adopted), that the disappearance of one degree Fahr. of heat in a pound of water could, when applied properly, raise 772 pounds one foot high, that is that it could produce 772 foot pounds, or that it could be transformed in 772 foot pounds. This is the so much talked about co-relation of forces. This agreed with the previous experiments of Count Rumford, who transformed horse power into heat and made it boil water, and with Mayers' experiments who produced heat by the compression of gases, producing a certain quantity of heat evolved by a certain power applied. All these were important steps and culminated at last in taking electricity in the domain of the co-relation of forces and determining by calculation how much current and voltage may be expected from a given power applied to a dynamo.

Priestly—Joseph (1733–1804); English physicist; was in his boyhood so very bright that, being intended by his parents for a theological career, he became quite familiar with the classical dead languages as well as with the principal living ones; then he entered a theological academy and ultimately became assistant minister, but only for three years, when he resigned for reason of his liberalism, such as a renunciation of the doctrine of atonement, etc. He then turned his attention to physics, worked with air pumps, electric machines, started a school and published, in 1767, a book entitled, "History and Present State of Electricity," which he had written with the assistance of books loaned to him by Franklin. He discovered oxygen and ammonia and the nitrous, carbonic, sulphuric and hydrochloric acid gases; invented pneumatic contrivances, and was, in fact, the founder of pneumatic chemistry. His liberal opinions irritated the orthodox, who instigated a riot, during which his house was destroyed with all its contents of books, apparatus, etc., he was compelled to flee so as to save his life, and came to this land of liberty in 1794 and went to Cumberland where his son had settled on a farm.

At the occasion of the centenary of the discovery of oxygen, 1774, his statue was unveiled at Birmingham, England, in front of the spot where his house had been distroyed by the mob, and on the same day, August 1, 1874, a number of American chemists celebrated that discovery at Northumberland, and at the same time that the statue was unveiled in England in the afternoon, they assembled in the forenoon around his grave, and after some eloquent addresses the following message was sent by cable to England:

"The American chemists assembled at the grave of Priestly for honoring his grand discovery of oxygen, send their greeting to the English chemists assembled around his statue in Birmingham."

To this telegram a corresponding answer was received before the adjournment of the meeting, and the writer of this short biography, who was present there, seeing around him, with the descendants of Priestly also, the most eminent scientists of America, all standing on the most picturesque burial place imaginable (being a hill around which the romantic valley of the Northumberland river winds itself), received impressions of which the touching recollections of the solemnity of the occasion will never be effaced during the rest of his life.

Telephonic News

*** Santa Fé expects to start a telephone exchange shortly with 25 subscribers.

*** A telephone line is talked of from Sebec station through the towns of Atkinson and Charleston, Me.

*** The Manchester, N. H., *Union*, states that a telephone line is to be erected between Manchester and Rochester in the Spring.

*** The telephone in Japan is growing in popularity. At Tokio there is a general familiarity with the instrument and its uses, and even in out-of-the-way districts it is not unknown.

*** The Boston *Post* says that "an authority estimates that the Bell Telephone's net earnings for the fiscal year just ended will not be very far from $3,098,971, or 20.7 per cent. on the $15,000,000 capital stock."

*** A telephone system for use in large factories has been invented, in which each telephone has its own switchboard, so that communication can be had with any telephone on the line by simply moving a switch.

*** E. O. Schock, manager of the Postal Telegraph Company at Reading, Pa., for the past three years, has been appointed division superintendent of the Lancaster county district of the Pennsylvania Telephone Company.

*** The Pennsylvania Railroad has established a telephone station at Pittsburgh in connection with the dispatcher's office at the Union depot. The lines will run to all the freight and passenger offices as far as Wilkensburg and be connected with the city central.

*** A clever bit of telephone work was done at Tewkesbury, England, on the occasion of the opening of the public call-room. The representative of a Tewkesbury paper had to transmit to Cheltenham a report of 700 words; he accomplished the same in three minutes, 230 words a minute.

*** The government telephone line between the Narragansett Pier, Point Judith and Watch Hill, R. I., stations has been completed, and when tested worked admirably. Col. Bolton, the government expert, and Capt. H. M. Knowles will begin work at once on the line to Block Island, thus connecting the half-way house and two stations of the Island with Capt. Knowles' office in Wakefield.

*** A telephone meter was recently suggested by Dr. Stieckel before the Frankfort Electrical Congress. The apparatus is described as simply an electric clock which is set going by the telephone being taken off the hook, and is stopped by the clearing-out signal being given. The plan suggested is, after charging a small uniform "fundamental tax," to fix the tariff according to the length of the conversation.

*** W. W. Nicholson, division superintendent of the Central New York Telephone Company, at Utica, N. Y., has been appointed to fill the position made vacant by the resignation of General Superintendent W. H. Girvin, of Syracuse. Superintendent Girvin has resigned to accept the position of general manager of the Syracuse Electric Light and Power Company. Mr. Nicholson will be succeeded as division superintendent by George W. Wood, of Little Falls, who has had charge of the Herkimer county business.

*** The *Boston News Bureau* makes the following statement: "We are able to announce that the American Bell Telephone Company has so far forwarded its experiments in the telephone field that it has now in its possession a perfected telephone by which whispers can be transmitted 500 miles as distinctly as though that 500 miles of wire were only five feet of space. Telephone connections between Chicago and the East will be only a matter of line construction. In fact, telephoning from Boston to San Francisco does not seem an impossibility in the near future. There are still difficulties of construction to overcome for a cable telephone service, but Puck's girdle 'round the world in 40 minutes, which seemed such a fairy tale for Shakespeare's time, may yet be beaten by 39 minutes and 59 seconds."

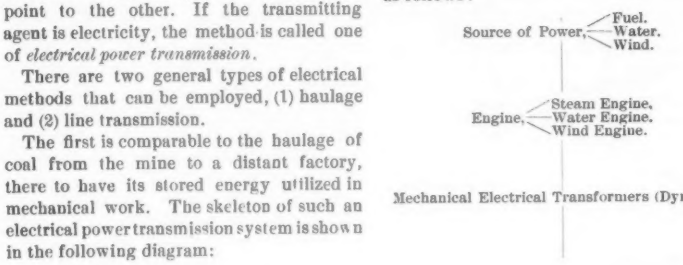
Long Distance Transmission of Power by Electricity.

A PAPER READ BEFORE THE SOCIETY OF ARTS, BOSTON, DECEMBER 29, 1891,
BY FRANCIS R. HART.

Given a point where power is best obtainable and another point where such power can be most advantageously used, the problem given to the engineer for solution is that of transmitting this power from the one point to the other. If the transmitting agent is electricity, the method is called one of *electrical power transmission*.

There are two general types of electrical methods that can be employed, (1) haulage and (2) line transmission.

The first is comparable to the haulage of coal from the mine to a distant factory, there to have its stored energy utilized in mechanical work. The skeleton of such an electrical power transmission system is shown in the following diagram:


Source of Power, Fuel. Water. Wind.
Engine, Steam Engine. Water Engine. Wind Engine.
Mechanical Electrical Transformers (Dynamos).

attached to air engines at a distant point, we have a system directly comparable with the electrical haulage plant.

The storage battery street car is an example of this method of electrical power transmission.

The other general type of electrical methods for distant delivery of power employs a line of conducting wires between dynamo and motor in place of the cumbersome system of haulage. The skeleton of this system is as follows:

Source of Power, Fuel. Water. Wind.
Engine, Steam Engine. Water Engine. Wind Engine.
Mechanical Electrical Transformers (Dynamos).

Wind: 1. Pumping (mines and irrigation); wind engine at best point and pump anywhere. 2. Lighting with storage cells.

In practice, except for street railway and mining work, fuel is not an economical source of power for long distance transmission plants. Ordinarily it is cheaper to deliver the coal at the distant point and obtain the power directly. In connection, however, with water-power the usefulness of an electrical power system can hardly be exaggerated.

Before describing to you the various systems that can be employed for line electrical power transmission, I wish to call your attention to certain points concerning the efficiency of such a method and how far we can govern this efficiency. We call the mechanical efficiency of a system the ratio of the power delivered to the dynamo-electric machines at one end of the line to the power delivered by the electric motors at the distant end.

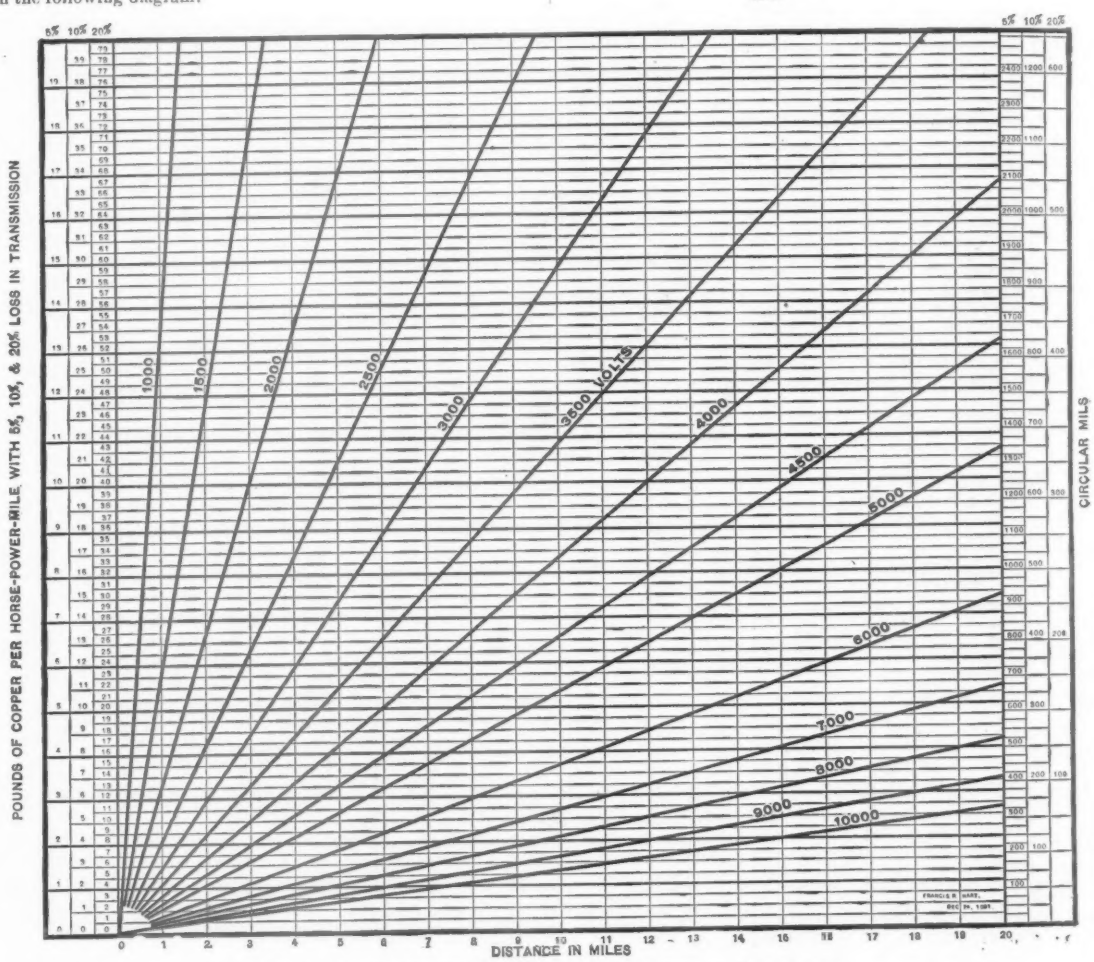
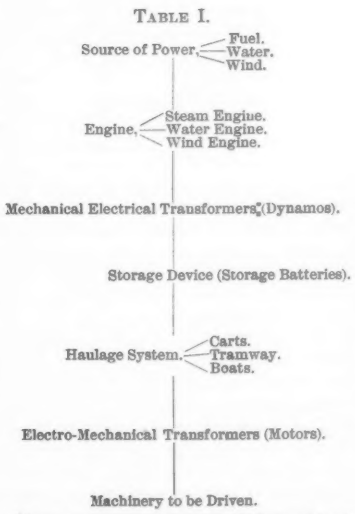
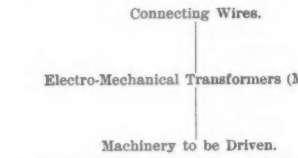


FIG. 1.—LONG DISTANCE TRANSMISSION OF POWER BY ELECTRICITY.

TABLE I.


Source of Power, Fuel. Water. Wind.
Engine, Steam Engine. Water Engine. Wind Engine.
Mechanical Electrical Transformers (Dynamos).
Storage Device (Storage Batteries).
Haulage System, Carts. Tramway. Boats.
Electro-Mechanical Transformers (Motors).
Machinery to be Driven.

More analogous than the haulage of coal to this method would be a compressed air system. If the steam engine or turbine at the source of power drove air compressors which filled portable vessels with compressed air, and these vessels were transported and



The second system has obvious advantages for long distance transmission and I shall consider with you that only. There are conditions, however, where even for other than tramway work the haulage system may be the only or best system that can be employed.

I have given *fuel*, *water* and *wind* as the three power sources which may be employed to drive a power system. Some of the uses to which electrical methods of transmitting power may be put are shown in the following table:

Steam: 1. Large number small users obtain more economical power from one engine. 2. Local distribution from lighting companies. 3. Street railways. 4. To replace long shafts. 5. Special works (mines, etc.).

Water: 1. Locate mill with reference to shipping conveniences. 2. Concentration of small water-powers. 3. Carrying power into cities for factories, street railways, etc. 4. Continuous use of power (power during day and lighting at night).

The commercial efficiency of a dynamo or motor, as I shall show you later, varies with its load. The maximum efficiency of good machines should not be under 90 per cent., and is seldom above 92 per cent. Under the most favorable conditions, then, we must expect a loss of, say, 9 per cent. in the dynamo and 9 per cent. in the motor.

The loss in transmission, due to fall in electrical pressure or "drop" in the line, is governed by the size of the wires, the other conditions remaining the same.

For a long distance transmission plant this will vary from five per cent. upwards.

With a loss of five per cent. in the line the total efficiency of transmission will be slightly under 79 per cent.

With a loss of 10 per cent. in the line the efficiency would be slightly under 75 per cent. We may call 80 per cent. the practical limit of the efficiency with the apparatus of to-day.

The methods for long distance power transmission by electricity may be divided into three general classes: (1) Those using continuous current; (2) those using alternating current; and (3) regenerating or "motor-dynamo" systems.

I have tabulated the subdivisions of each of these general classes, as follows:

- Continuous current.
  - 2-wire.
    - Low voltage.
      - One machine.
      - Machines in parallel.
    - High voltage.
      - One machine.
      - Machines in parallel,
      - Machines in series.
  - 3-wire
    - 2 Machines in series.
    - Machines in multiple series.
  - Multiple wire. — Machines in series.
- Alternating current.
  - Alternating single phase.
    - Without conversions (1).
    - With conversions (2).
  - Alternating multi-phase.
    - Without conversions
    - With conversions.
- Regenerating systems.
  - Alternating-continuous.
  - Alternating converter, line converter, alternating-continuous.
  - Continuous-continuous.
  - Partial reconversion of any system.

The system selected must, first, fill construction and operation conditions, and second, give minimum cost per horse-power delivered. There are many factors which govern the selection of a system. For each problem considered there will be found certain fixed and certain unfixed conditions.

In general the fixed factors are as follows:

1. Capacity of source of power. 2. Cost of power at source. 3. Cost of power by other means at point of delivery. 4. Danger considerations at motors. 5. Operation conditions. 6. Construction conditions (length of line, character of country, etc.).

The partly fixed conditions are:

7. Power which must be delivered (*i. e.*, the efficiency of the system). 8. Size and number of delivery units.

The variable conditions are:

9. Initial voltage. 10. Pounds of copper on line. 11. Original cost of all apparatus and construction. 12. Expenses, operating. (Fixed charges, interest, depreciation, taxes, insurance, etc.) 13. Liability of trouble and stoppages. 14. Danger at station and on line. 15. Convenience in operating, making changes, extensions, etc.

Assuming that the cost of dynamos, motors, etc., will be approximately the same, whatever the initial pressure, I shall show you the great variation in the cost of wire at different pressures. For convenience in working out such problems for rapid and approximate determinations, I have drawn a diagram or chart, Fig. 1, from which can be determined the pounds of copper required for transmitting any number of horse-power from one to 20 miles with an initial pressure of from 1,000 to 10,000 volts, at various losses in transmission. The scale of ordinates on the left gives the total pounds of copper required for one horse-power for each mile transmitted, at 5 per cent., 10 per cent., and 20 per cent. loss in transmission. The scale of ordinates on the right gives the area in circular mils of one of the two necessary wires at the same percentage losses.

To illustrate the use of the diagram, suppose we wish to know the weights of copper required for transmitting 100 horse-power five miles at 2,000, 3,000 and 10,000 volts, and at 10 per cent. and 20 per cent. loss, respectively. By inspection of the diagram we obtain the following figures:

Voltage.	Drop. per cent.	Total Pounds Copper.
2,000	10	33.6×100×5=16,800
	20	16.8×100×5= 8,400
3,000	10	14.8×100×5= 7,400
	20	7.4×100×5= 3,700
10,000	10	1.24×100×5= 620
	20	.62×100×5= 310

Very interesting mathematical deductions can be made showing conditions which give minimum cost, maximum efficiency, etc., but in practice these become of small value as almost invariably there are fixed construction or operation conditions which cannot enter as factors in a derived formula.

In the limited time left to me I can do no more than indicate to you the details of the construction and operation of an electrical power plant. I shall take as an example an installation where the source of power is water. We may separate the details of construction and operation into four heads—hydraulic, mechanical, electrical and financial. Under "hydraulic" come the improvement, control and care of the water privilege; the selection, placing and care of turbines, and the turbine regulation.

A good turbine, working at its proper load, will deliver from 75 to 80 per cent. of the total energy of the water. If over or underloaded to any extent the efficiency is diminished. For the most efficient and economical working of a plant it is, therefore, necessary to exercise care and judgment in the management of the turbines.

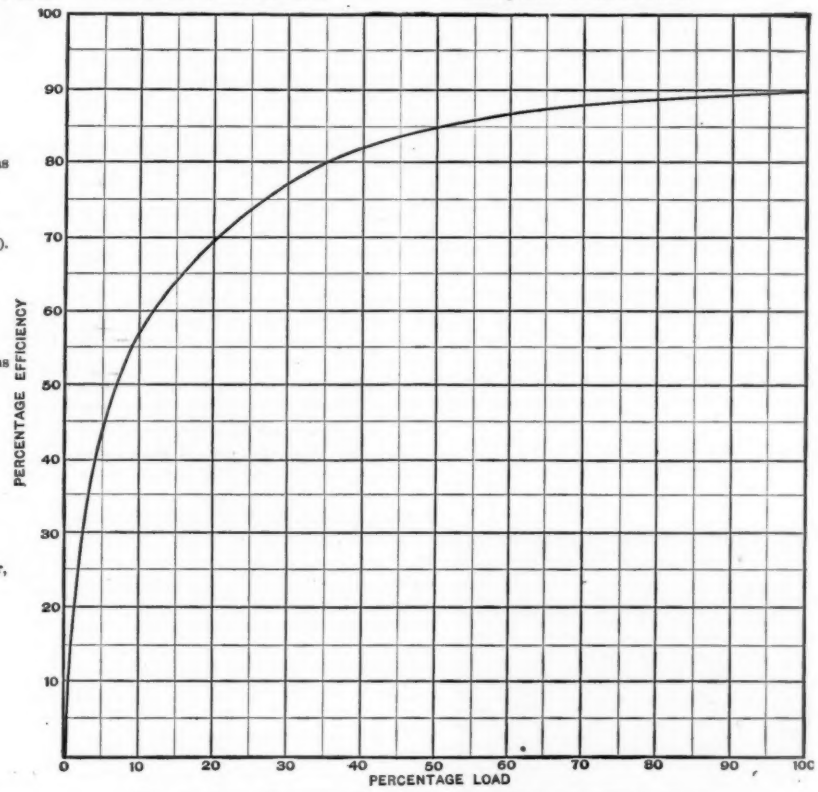


FIG. 2.—LONG DISTANCE TRANSMISSION OF POWER BY ELECTRICITY.

Under the head of "mechanical" details of construction and operation belong the selection and care of shafting, gears, belts, clutches, etc. It is customary to so arrange the mechanical parts that any or all turbines or dynamos may be thrown into or out of use without affecting the running of the plant. That is, where possible, all like units should be interchangeable without interfering with the operation of the plant.

Under the head of "electrical" we have: Line construction and maintenance; machine construction, installation and maintenance; construction of switchboard, selection, construction and care of measuring instruments, lightning arresters, etc.; provision for extra parts of machinery and conveniences for rapidly making necessary changes.

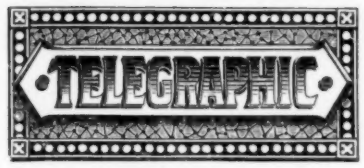
The same care exercised in keeping the turbines at maximum efficiency should be applied to the dynamos. The curve, Fig. 2, shows the average variation in efficiency with load of dynamo-electric machines of from 25 horse-power to 75 horse-power.

In all such plants complete records, in the form of daily reports, should be kept of pressures, currents, speeds, heights of water, time machines are started and stopped, etc. A monthly statement should be made showing the averages of the daily reports and all expenses for the month. It is convenient to deduce from each monthly statement, for a uniform basis of comparison, the cost per horse-power delivered for a stated time.

As the chairman, Professor Cross, so kindly referred to the transmission plant at Cumberland Mills, Maine, which was designed and installed by the Massachusetts Electrical Engineering Company, a brief description of that plant may be of interest. The source of power is the Piesmuscot river. The turbines are vertical "Hercules" wheels working under a head of 12 feet. There are five 80 horse-power dynamos at Saccarappa, and one mile away, at Cumberland Mills, are six motors, delivering power to the paper mills. The system is three-wire, with a maximum pressure of about 1,100 volts. The wires are bare copper, with a sectional area each of 167,805 circular mils.

The relative advantages of these systems vary with each particular transmission problem, but in a general way may be tabulated as follows:

	System.	Advantages.	Disadvantages.
Continuous.	2-wire. Low voltage.	Safety, simplicity.	Expense for copper.
		Economy, simplicity.	Danger, difficulty of building machines.
	2-wire .. .. High voltage.	Low voltage on machines and saving in copper.	Not saving enough in copper for long distances. Necessity for "balanced" system.
	Multiple-wire.	Low voltage at machines and saving in copper.	" " " "
	Single phase.	Economy of copper.	Cannot start under load. Low efficiency.
Alternating.	Multiphase.	Economy of copper, synchronous speed unnecessary; applicable to very long distances.	Complexity. Lower efficiency of terminal apparatus. Not as yet "standard" apparatus.
	Motor-dynamo.	High voltage transmission. Low voltage delivery.	Expensive. Low efficiency.



.... The Gamewell Police Telegraph System is to be introduced in Savannah, Ga.

.... The Postal Telegraph Company have completed their line to San Diego, Cal., and are now ready for business.

.... The Western Union Telegraph Company will open an office in the Hotel Warwick building, at Huntington, W. Va.

.... C. M. Baker, Genl. Supt. of Construction, and J. W. Waterman, Supt. of Construction, of the Postal Telegraph Company, were in Des Moines, Ia., on the 22d ult.

.... D. G. Sims, of Mobile, Ala., was installed on the 22d ult., as manager of the Western Union Telegraph Company at Atlanta, Ga., *vice* Dr. Price E. Murray, resigned.

.... The Postal Telegraph Company has completed its line from Savannah, Ga., to Charleston, S. C., by the country roads, instead of following the railroad. A cable was laid across the Savannah river, opposite the city.

.... The postmaster-general of Great Britain recently announced in the House of Commons that the telegraph service had during the last official year produced a surplus for the first time since the introduction of the present rates in 1883.

.... Capt. John Bragg, Associated Press operator in the Western Union Telegraph office at Wilmington, N. C., died on the 30th ult., from an attack of the grip. He was a son of the late Gov. Bragg, and had been a resident of Wilmington for the past seven or eight years.

.... At the recent annual meeting of the Northern Telegraph Company, at Manchester, N. H., Ex-Gov. Frederick Smyth was re-elected president and Hon. Chas. H. Bartlett, treasurer. Hon. Frederick Smyth, Hon. C. H. Bartlett and Arthur E. Clarke, were elected directors. A dividend of three per cent. was declared.

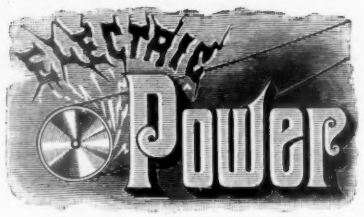
.... The Western Union Telegraph Company, in 1870, had 112,191 miles of wire, 3,971 offices, sent 9,157,646 messages, at an expense of $4,910,772, and at a cost to the public of $7,138,738, thus netting $2,227,966 profit. It now has 678,997 miles of wires, 19,382 offices, and last year sent 55,878,762 messages, for which it received $22,388,029, at an expense of $15,074,304, with a profit of $7,312,725. The average toll per message was $1.04 in 1868, 78 cents in 1870, 43¾ cents in 1880, and 31¼ cents in 1890.

.... Judge Bischoff, of the Court of Common Pleas, recently denied the motion of the Gold & Stock Telegraph Company for a permanent injunction restraining the New York Stock Exchange from cutting their wires and withholding their quotations. This decision is in accord with that recently given by Judge Dykman at White Plains, in the case of the Consolidated Exchange, and that of Judge Van Brunt at General Term, to the effect that the quotations are the property of the Exchange to do with as they please. The wires were cut and quotations withheld for several days, as the result of this decision, but on the 8th inst. a temporary agreement was entered into, under which the Gold & Stock Telegraph Company agree to pay $100 per day for the quotations.

More Calendars.

Pinkham & Godfrey, electrical engineers, 38 Bedford street, Boston, issue a large calendar carrying a handsome picture, in colors, of a fox terrier.

The Eureka Tempered Copper Company North East, Pa., is sending out a neat calendar on which is printed a reproduction of "The Angelus" in colors.



* * Lancaster, Pa., has decided to build an electric railway to Lititz.

* * There is talk of an electric railway for Laramie, Wyoming, next Summer.

* * It is proposed to construct an electric railway to connect Barre with Strafford, Vt.

* * Anthony Shirner, of Auburn, N. Y., is talking of building an electric railway between Auburn and Genoa.

* * A charter has been granted for an electric street railway to the Port Norfolk, Va., Electric Railway Company.

* * It is stated that a company is being organized to build an electric road from Canfield to Lauterman's Falls, O.

* * The electors of Peterboro, Canada, voted the electric street railway franchise to the Edison syndicate on December 24.

* * The Atlanta, Ga., West End and McPherson, and the Grant Park Electric Street Railway lines have been consolidated.

* * A charter has been granted for an electric railway between Lancaster, Pa., and New Holland. The road will be 14 miles long.

* * The Union Trust Company, of Philadelphia, has taken a mortgage of $125,000 on the Mahanoy City, Pa., and Ashland Electric Railway.

* * A new electric railroad is likely to connect South Bethlehem, Pa., Emaus, Hellertown, Springtown, Freemansburg, Butztown and Nazareth.

* * Janesville, Wis., will have an electric railway. Haines Bros., of Kinderhook, N. Y., guarantee that the road will be in operation on or before July, 1892.

* * Mr. Alexander Russell, of Santa Cruz, Cal., is proposing to build an electric railway there, provided the council accept certain very favorable propositions which he has made.

* * In the new battleship of 11,605 tons, recently contracted for by the French Admiralty, electricity will be used for turning the turrets, closing the ports and driving auxiliary machinery.

* * The Poorman Mine in the Cœur d'Alene coal region is soon to be operated altogether by electricity. Two dynamos of 250 horse-power each, operated by water power, are to be put in.

* * An execution in behalf of the Edison General Electric Company has been filed against the McKeesport, Pa., Electric Light Company. The execution was on a bond for $25,000, the real debt being $9,830.35.

* * Some McKeesport, Monongahela City and Allegheny City capitalists are considering the erection of an electric railway from the terminus of the Fifth avenue line now in that city out through the suburbs to Sampson's mill.

* * The Milwaukee and Wauwatosa Electric Railway Company have decided to purchase the plant of the Wauwatosa Electric Company in order to obtain additional power for running their road. New dynamos will be put in at once, and other additions and alterations made which will greatly increase their facilities.

* * The Lowell, Mass., and Suburban Street Railway Company has filed a mortgage on its property for $1,000,000 to the American Loan and Trust Company, of Boston. The bonds are to be $1,000 each, running 20 years at five per cent. The money will be used for extensions and for equipping the road with electric power.

Polyphased Alternate Currents.

BY "E. H." IN LONDON "ELECTRICAL REVIEW."

All the apparatus that we have mentioned up to the present work with three wires and three currents, under conditions of perfect symmetry, as we showed at the beginning of this series of articles. We have now to speak of the properties of two-phased alternate currents, the study of which will be greatly facilitated by what we have already found out with regard to triphased currents, and we shall follow the same order in discussing them.

GENERATORS.

The first generator of diphased alternate currents was clearly described in Nikola Tesla's American patent, No. 381,968, dated May 1, 1888 (application filed October 12, 1887), as a generator capable of working a synchronic revolving field motor. This generator consisted, essentially, of two bobbins connected at right angles on the same cylindrical armature in the magnetic field produced by suitable inductors. It was a generator with four wires and three currents, but the number of wires can easily be reduced to three by rendering common any two of the wires belonging, respectively, to each circuit. The diphased alternate current generators shown by M. Schuckert at Frankfort, in the transport of motive power established between the Palm Garden and the exhibition, differs in principle from M. Tesla's in the crossing of the circuits, which altogether prevents the employment of a common return wire, and necessitates the use of four wires proceeding from the generator. Fig. 1 shows the winding of this generator, consisting of a simple Gramme ring revolving with a uniform angular speed

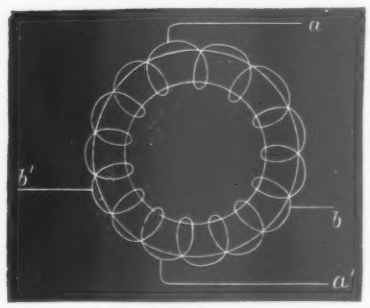


FIG. 1.—DIAGRAM SHOWING THE CONNECTIONS OF A SCHUCKERT ALTERNATE DIPHASED GENERATOR.

in the magnetic field produced by inductors excited by a separate current.

On the winding of this ring four collections of current are taken, the two points diametrically opposite, a a', communicate with one circuit, and the other two diametrically opposite points, b b', communicate with the second circuit. As the ring is movable, and the inductors fixed, the permanent connections between the four points of the generator and the four conductors are established by means of four collecting rings and four brushes, which are not shown, in order not to complicate the diagram. It would, moreover, be easy to reverse the arrangement by leaving the induced ring fixed, and making the inductors turn. In this case we should get permanent communication between the generator and the outer conductors; two rings and the two brushes are sufficient to bring the exciting current to the movable inductors, as in Brown's triphased generator, which has already been described.

On examining this generator more closely, we see that if the circuits traversed by the two alternate currents are clearly separated on leaving the armature, they are common in the armature itself; each quarter of the ring is traversed, at each instant, by the algebraic sum of the two outer currents taken with different signs, according to their connections.

Many other combinations might be employed in order to realize a diphased alternator; but we merely mention those that have been practically realized and applied to some practical use.

TRANSFORMERS.

We have just seen that the diphased alternate current generators generally contain *four wires*. For reasons of economy on the one hand, and reduction of danger on the other, these generators are made of low tension; it is therefore necessary to transform these currents when they are to be transported to a great distance. The transformer effects this transformation, and, moreover, enables the four wires to be reduced to three along the line of transport. Fig. 2 shows how this result is easily obtained by a suitable combination of the inductive and induced windings.

In fact, a double transformation is generally resorted to, so as to reduce upon arrival the high potential of the line, and to work at low tension on the utilizing apparatus. The Frankfort installation is a typical instance of this double transformation which enables us to have again, upon arrival, the two lagging circuits, perfectly distinct and independent, with four wires instead of three.

The diphased transformer employed by M. Schuckert to transform the 100 volts furnished by the dynamo into 2,000 volts, and again to re-transform upon arrival the 2,000 volts into 100 volts, is shown as a whole in Fig. 3, and the details of its construction in Fig. 4. This multiple transformer belongs to the class of apparatus with a closed magnetic circuit, and consists, in principle, of two annular disks of soft iron. The thicker of these two disks is provided with radiating slots of rectangular section, into which fit the elementary inductive and induced bobbins, which are triangular in form. These bobbins contain windings, the numbers of which are in the same ratio as the coefficient of transformation, and each of them forms a complete group. In the model shown there are twelve radiating slots, into which can be fitted six pairs of bobbins, three pairs for each of the two currents. We can, moreover, modify within considerable limits the ratio of transformation by modifying the coupling of the different bobbins, according to whether they are connected in series or in quantity. The magnetic circuit is closed by adjusting on the first disk furnished with its bobbins the second disk forming a sort of lid for the bobbins. To avoid all danger, the two disks are connected to earth.

This arrangement of the transformers is one of the most simple, and has the advantage of being applicable, if the bobbins are suitably coupled, to ordinary alternating currents as well as to diphased and triphased alternating currents.

APPLICATIONS.

As with triphased currents, it is possible to apply diphased alternate currents to lighting and to motive power, and to transform them into continuous currents for those applications in which electrical energy can only be utilized under the form of continuous currents. Space does not permit of our entering further into the application of these currents to lighting, the incandescent lamps being connected in derivation on each of the

FIG. 2.

Diagram showing the double transformation of diphased alternating currents (first from 100 volts to 2,000 volts, second from 2,000 to 100). The two circuits are perfectly separated on departure and arrival, but have a common return along the line of high tension transmission.

two distinct circuits. We will merely say a few words about motors and the apparatus employed for transforming these currents into continuous currents.

MOTORS.

The diphased current motors really preceded the triphased current motors. They are synchronic or asynchronic. Although we cannot speak positively on this subject, it seems that the asynchronic motors were invented independently, and about the same time, in Italy by Professor Ferraris and in America by M. Nikola Tesla. In both cases the researches and experiments date as far back as 1886, but M. Ferraris' motor was not made public until March, 1888, in the *Atti della R. Accademia delle Scienze di Torino*, and the patents granted to M. Tesla, which were applied for in October and November, 1887, were not published until May 1, 1888.

Fig. 5 shows the principle of Professor Ferraris' two current motor; it is reproduced from the original paper. We see here two rectangular circuits, traversed by two currents, with a lag of a quarter of a period, producing the rotation of a copper cylinder placed in their midst. The theory of the working is the same as that of the three-phased synchronic motor, so that we need not discuss it further. We may mention, however, that Professor Ferraris, at that time, did not consider that a revolving field motor had any industrial importance, even although he was studying its dimensions in order to increase its power and ameliorate its efficiency (page 10 of the report), whereas M. Tesla took out his patents quite aware of the industrial importance to which revolving

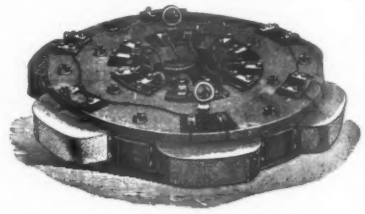


FIG. 3.

field motors might attain. In fact, they have been applied in America to certain purposes which our American *confreres* have vaguely mentioned; so vaguely, indeed, that it is difficult to say to what extent these applications have met with industrial success. We may say that up to the present there does not exist, *in Europe*, a real industrial asynchronic motor with diphased currents. We do not know how many are in existence in America, and should be glad to receive information on this point.

The same remark might be applied to synchronic motors with diphased alternating currents, for the only case that we can mention is that of the transport of power established at Frankfort, and the motor worked at the exhibition constituted rather a multiple transformer than a motor, properly so called.

DIPHASED MULTIPLE TRANSFORMERS.

All that we have said with regard to triphased current multiple transformers applies equally well to diphased current multiple transformers. In fact, M. Schuckert exhibited at Frankfort a *generator-motor with continuous currents and diphased alternating currents* similar in principle to that which we described in our last article. This apparatus is shown in Fig. 6. It consists of a Gramme ring furnished with its collector, and moving in the field produced by inductors arranged along the two surfaces of this flat ring. Four points, 90 degrees apart, are taken in the winding and connected with four metallic rings, insulated from one another, and against which press four rubbers.

This apparatus, constituted in this manner, may perform six distinct functions: 1, it may act as a continuous current generator; 2, as a self-exciting diphased alternate current generator; 3, as a continuous current motor; 4, as a diphased alternate current motor; 5, as a transformer of continuous currents into diphased alternate currents; 6, as a transformer of diphased alternate currents into continuous currents. It was this sixth and last function that was performed by the apparatus exhibited at Frankfort by M. Schuckert.

The high tension alternating currents (2,000 volts) issuing from the first transformer placed in the Palm Garden arrived at the exhibition by three wires, and were received into a second transformer where they were brought back to the potential of 100 volts, and separated into two distinct circuits with four wires. These four wires communicated with the four rings of the apparatus, which rings are shown at the left of Fig. 6.

The diphased alternate currents passing through the ring tend to produce in it a revolving magnetic field. This field reacts on the inductors, the circuit of which is at this moment open. This produces a motive couple which tends to turn the armature in the same direction as the field and synchronically with it. When synchronism is established all we can do is to close the circuit of excitation on the brushes of the continuous current collector, in order to excite these inductors permanently and ensure this synchronic rotation between the generator motor and the frequency of the diphased currents which feed it.

The continuous current canalization is branched on these same brushes, so that from the moment when synchronism is attained and the circuit of excitation closed, we get continuous current supplied by the transformation of diphased alternate currents. This continuous current served at Frankfort to feed continuous current motors of low power, working different implements in the gallery constituting the workshop, so that the electrical energy *produced* at low tension in diphased alternate currents on *four* wires was *transported* at high tension in diphased alternate currents on *three* wires, *transformed* into low tension alternating cur

rents on *four* wires, and, lastly, re-transformed into continuous currents on *two* wires. The experiments of the trial committee will show at what cost all these transformations of energy were effected, and, considering the contradictory opinions expressed as to polyphased alternate currents, the sooner the better.

Conclusions.—After this rapid sketch of the properties of polyphased alternate currents, the reader will be convinced that they have many curious and interesting properties, and that as they constitute, as has sometimes been said, a third form of electrical energy, these special properties are worthy of being more fully discussed than in these articles, in which we have given a brief survey of the question. We shall, moreover, soon be enlightened as to the industrial and commercial value of this new branch of electrical engineering by the experiments of the

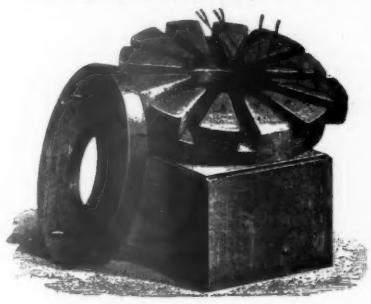


FIG. 4.

Frankfort Committee and the results of the transmissions of motive power now being established with polyphased currents in different parts of Europe.

The present importance of these currents may be greatly diminished by the discovery of a simple alternating current motor starting with a load, or by that of an apparatus capable of transforming simple alternating currents economically into continuous currents. It is also possible, and even probable, that polyphased currents will constitute merely a *transitory* system of transmitting electrical energy to a distance, as the Jablochkoff candle constituted a transitory system between the arc lamp and the incandescence lamp.

However this may be, polyphased currents will mark a new era in electrical industry; if their life is to be short, it will at least not have passed without honor and interest.

A Reporter Sees Electricity.

Two more new Edison dynamos have been placed in operation in the electric light works. They will run the street and business arc light circuits. The company is putting in Thomson-Houston arc lights in the business places and on the streets about town.

"Did you ever see electricity?" asked Electrician Max Meyer, of a reporter last evening. The reporter replied in the negative, and Max equipped him with a pair of black spectacles, mounted him upon a step-ladder and directed him to look steadily at the point of contact of the two carbons. The reporter followed instructions.

"Do you see a blue streak of something rushing from one carbon to the other?" asked Max.

"I do," said the scribe.

"Well, that's electricity," said Max, "and that is the only way in which the mysterious power can be seen."

Then the meeting adjourned.—*West Chester, Pa., News.*

The Company Must Pay.

Justice O'Brien, of the supreme court, has decided that the United Lines Telegraph Company will have to pay the assessment levied by the city of New York to pay the expenses of the subway commission. The United Lines Telegraph Company brought suit against the city to prevent Mayor Grant from collecting the money. When the assessment was made the company's lines were operated by the Postal Telegraph and Cable Company.

The act of the legislature appointing the subway commission provided that the different companies which had electric plants in New York State should pay the expenses of the commission, which amounted to $80,000. The amount assessed against the United Lines Company as its proportion of this amount was $2,201. Part of this was paid before this suit was begun.

The United Lines Company claimed that the city of New York was not assessed anything, although it operated more wires than the plaintiff company. It also charged that the act creating the subway commission was unconstitutional.

Justice O'Brien's decision is against the telegraph company on every point raised.

Governor Flower's Message.

Governor Flower's message, presented to the New York Legislature on January 5, has this to say about electrical executions:

During the past year and a half there have been several executions of convicts sentenced to death in the State prisons, under the provisions of what is popularly known as the "electrical execution" act, passed in 1888. The results of those executions have been regarded by expert witnesses as a satisfactory vindication of the new method of inflicting the death penalty, furnishing, it is said, a speedy and painless death, and being less revolting in its operation than was the old method of hanging.

There is one feature of the law, however, which is of doubtful constitutionality and of questionable propriety. I refer to that provision which prohibits the newspaper publication of an account of the details of the execution. The exact reading of the law upon this point is as follows:

"No account of the details of any such execution, beyond the statement of the fact that such convict was on the day in question duly executed according to law, at the prison, shall be published in any newspaper. Any person who shall violate or omit to comply with any provision of this section shall be guilty of a misdemeanor."

This provision of law has been generally disregarded by the newspaper press. In my opinion, it was unwisely made a part of the statute. The adoption of so novel a method for inflicting the death penalty as electricity naturally excited world-wide attention and aroused both popular and scientific interest. There was in the beginning some question of its success. The public curiosity to know the actual results of the experiment was intense. It did not spring from morbidity, but from wholesome interest. The feeling was general that so radical and important a departure

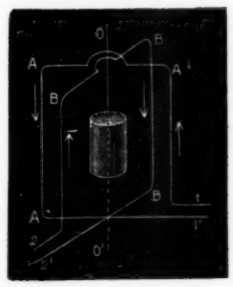


FIG. 5.—PRINCIPLE OF PROF. FERRARIS' REVOLVING FIELD MOTOR.

from existing methods should be carefully studied and the facts relating thereto truthfully stated. There is a popular aversion to secret methods of performing public duties.

In response to this sentiment the newspapers at the time of the various executions contained long and graphic accounts of what purported to be accurate descriptions of the details of the executions. If the descriptions were accurate the law was deliberately violated. If they were inaccurate the public was grossly imposed upon. In any case this provision of the law is not sustained by public sentiment and is practically a dead letter.

I, therefore, recommend its repeal. I have no sympathy with that morbid taste which yearns for revolting details of human suffering and misfortune and would make heroes out of criminals, but I recognize a legitimate public interest in the adoption and trial of this new method of execution, and I would not shut out from the people the opportunity, under proper restrictions, of securing the most unbiased information regarding its operation.

Other legislation has also been suggested to facilitate the operation of the statute providing for electrical executions. The infliction of death by electricity requires expert supervision and perfect appliances. These, it has been thought, are not always easily attained in the State prisons. Besides, the cost of establishing and maintaining the necessary apparatus in each prison is considerable, and should be avoided if practicable. I would respectfully invite your attention, therefore, to the recommendation of the superintendent of prisons, that the statute be amended so as to provide for but one plant, in a building especially constructed for the purpose and containing the necessary rooms and apparatus, under the charge of a competent and trustworthy electrician. My own opinion is that, should it be deemed advisable to adopt this suggestion, the plant should be connected with one of the largest and most accessible prisons, rather than established separately. This would be more practicable and more economical.

The World's Fair is mentioned as follows:

The legislature has yet made no provision for the proper representation of the State at the World's Fair in Chicago next year. This should be one of the first acts of your honorable body. The time is growing short for the erection of a suitable building for the exhibition of the State's interests, and if New York is to be represented commensurately with its commanding position and great resources, speedy legislative action is necessary. This duty the State owes to its commercial and industrial interests. The provision for State representation and participation should be liberal, but not extravagant. Our citizens will not begrudge an appropriation of public money for this purpose which will enable the State to be properly represented, but they will disapprove any extravagant expenditure, and will insist that whatever appropriation is granted shall be wisely expended under competent direction.

A New Use for the Incandescent Lamp in Photographic Studios, Etc.

Those who, from an amateur or professional standpoint, have had anything to do with photography, are well aware of the importance of stability in their various installations; vibratory motions of the supports, etc., are fatal to good results, and hence a small vessel of mercury is commonly used in order to indicate whether the apparatus is steady.

A much more delicate test of stability is an incandescent electric lamp. The mobility of the filament is extreme; it responds to to the least vibration; and this is especially the case if the continuity of the filament be interrupted. A lamp that would otherwise be thrown aside as useless for illuminating purposes may thus be made to serve a useful purpose.

It will easily be understood that the length of the filament is a condition of its sensitiveness to vibration, hence the Swan lamps are to be recommended for this particular use. But it must not be supposed that a lamp with an imperfect "vacuum" will do, for when air has leaked into the bulb it opposes a resistance to the vibrations of the filament, and hence it becomes not nearly so sensitive. Neither is a lamp that has been blackened by the "bombardment" of the carbon particles at all suitable, because then the delicate movements of the filament are perceived with difficulty.

To use the incandescent lamp for the purpose described is by no means the only use, of this order, to which it can be applied. We all know from sad experience the annoyance of vibratory movement in our testing rooms, and in order to get rid of it great expense must often be incurred, and separate foundations must be given to each floor, as in the Cavendish Laboratory at Cambridge. And it is very difficult to determine whether there is much vibration until the instruments have been properly installed.

But now the incandescent lamp test can be applied. It was used recently by Mons. F. Leconte, at the Institut des Sciences de Gand. He required to verify the stability of the stone supports which rest upon the foundations in the laboratory of physics there. Upon one of these supports he placed a telescope, and upon the other a Khotinsky

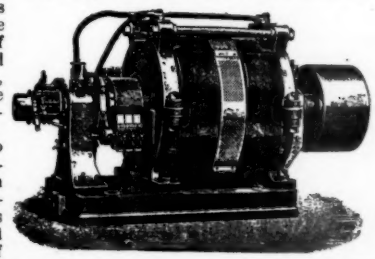


FIG. 6.—GENERATOR MOTOR FOR CONTINUOUS AND ALTERNATING DIPHASED CURRENTS.

lamp, and he made such dispositions and arrangements that the vibrations of the filament could readily be observed through the telescope. He waited about 10 minutes until there was complete repose, and then gave several sharp taps upon the floor of the laboratory, noting the number of seconds taken by the filament in again coming to the state of rest. The usual mercury tests were entirely incompetent to show vibrations which the incandescent lamp readily responded to. With a little care, this test of stability might be made of a quantitative nature, and thus its usefulness would be greatly enhanced.

Should our readers be further interested in this experiment, they will find a paper by Mons. Leconte in one of the recent issues of the *Bulletin de l'Association Belge de Photographie.*—*London Electrical Review.*

ELECTRIC LIGHT NEWS

—— The Boston Electric Light Company has increased its quarterly dividend from 1¼ to 2 per cent.

—— The Dubuque, Ia., city council is arranging to have the streets of that city lighted by 300 electric arc lights.

—— Manchester, Va., is about to advertise for bids for electric lighting for the next two years. The committee on finance and electric light are considering the advisability of securing an electric light plant for the city.

—— The Thomson-Houston Company has just closed a contract with the government for the erection of an electric light plant in the navy yard at Norfolk, Va. The yards, shops and officers' quarters will be lighted by this plant.

—— The Long Island City common council have granted a contract to the Long Island City Illuminating and Power Company to supply the principal streets of the city with electric lights, at the rate of $160 per lamp per year. The number of lamps will be settled upon later.

—— A quarterly dividend of two per cent. will be paid on the common stock of the Northwest Thomson-Houston Electric Company on January 15, 1892, to stockholders of record at close of business January 5. The transfer books will be closed from January 6 to January 15, both days inclusive.

—— The electric light plant being erected at Key West, Florida, is a source of great curiosity to a great many of the natives, who have never seen any thing of the kind before. The three large compound engines furnished by the Ball Engine Company, Erie, Pa., are the center of attraction, the largest engine on the island hitherto being an antiquated six horse-power.

—— The Municipal Electric Light & Power Company, of St. Louis, has decided to throw up its contract to light the city of St. Louis unless it gets $125,000 a year more than it is now getting. It says it is losing money at its present rate of payment. The city, under the company's charter, can buy it out if it so desires. The demand of the company means $1,000,000 more for lighting the city, as the contract has eight years to run. The present contract calls for $74.95 per arc light, and the city uses about 2,300. The company has $2,600,000 invested, but does some private lighting.

—— The Clinton, Iowa, Gas Light and Coke Company has lately purchased the electric light plant owned by the State Electric Company, and will in the early Spring remove it to the grounds of the gas works on North Twenty-second street, where a new brick building 46x96 is being erected for it. A Corliss engine of 350 horse-power capacity has been ordered of the Bass Foundry and Machine Company, of Fort Wayne. This and two engines of 125 and 150 horse-power will furnish the power. The boiler iron was ordered of Park Bros., Pittsburgh, and boilers constructed by the Star Boiler Works, of Clinton.

—— An interesting case decided by the court of appeals last week was that of the trustees of the village of Geneva, appellants, against the Brush Electric Company, of Cleveland, O. The electric company maintained an electric light pole in the village street, and a resident of the village was injured by colliding with it. He recovered damages against the village and the village sued to recover from the company. The general term decided in favor of the company, and the court of appeals upholds that decision upon the ground that the village trustees should have ordered the pole removed if they deemed it a public nuisance.

On Polyphasal Generators.

DISCUSSION OF DR. M. I. PUPIN'S PAPER, READ BEFORE THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, DECEMBER 16, 1891.

Mr. Charles Steinmetz: Having had the pleasure of hearing Professor Pupin's paper at the New York Mathematical Society some days ago, I might be allowed to make the same remark I made there, that it would be perhaps more advisable to use a shape of the electromotive force similar to Fig. 7, than the shape in Fig. 8; because, as you see, in shape Fig. 8, the curve has a sharp corner, and even if we could produce waves of electromotive force that have sharp corners, it can hardly be expected that we can derive from such a sharp cornered electromotive force a current, which after being sent through step-up transformers, over lines of considerable electrostatic capacity, and again through step-down transformers into a motor of high self-induction, would still have retained this sharp cornered shape. But the theory requires that the electric *current* in the motor has the shape given in Figs. 6 to 8. Even if the electromotive force had the shape of Fig. 8, the current in such a highly inductive circuit would differ considerably, having lost the sharp corners, etc. Hence Fig. 8 would be less recommendable. But the shape of Fig. 7 might easily be chosen so that there would be no sharp corners, but a steady and continuous variation, as shown in the sketch herewith.

Then with regard to the equations of the currents x, y, z, on page 15, I wish to make a remark. As stated by Dr. Pupin, the complex harmonic of the electromotive force produces a current which is a complex harmonic, too, and it is, identically the same complex harmonic as long as the circuit has no self-induction and no capacity or what amounts to the same, as long as self-induction and capacity have a certain ratio with each other. But as soon as the circuit has self-induction the complex harmonic of current differs from the complex harmonic of electromotive force, and differs the more the heavier the self-induction of the circuit is, by the decrease of the higher terms of this infinite series of simple harmonics which constitute the complex harmonic of electromotive force, these having a high self-induction; and, therefore, if we produce such a type of electromotive force and let it send a current through an inductive circuit it will probably break to pieces entirely, and show a current resembling a simple sine wave as closely as one egg to another. In the equations for x, y, z, on page 15, as the condition that the shape of the current does not differ from the shape of the electromotive force was found, that the second term, $m^2\ p^2\ (L\text{-}M)^2$, can be neglected against the first term R^2. This means, in *plain language*, that the shape of the current wave is the same as that of the electromotive force if the *self-induction of the circuit is negligible*. For the first term R is the *resistance*, the second term, $m\ p\ (L\text{-}M)$, is the *inductance* of the circuit.

Hence, neglecting the second term means neglecting the inductance, that is, it means that the motor circuit has no self-induction. Now, anybody who ever tried to design an alternating motor has found out—to his disgust, generally—that the self-induction of such a motor, even under the most favorable conditions, is anything but negligible. Unfortunately, I could not get any data on these rotary motors, but on some other alternate current motors I can give data. In the Ganz & Company synchronous motor the plant efficiency is claimed, by the manufacturers, to be 90 per cent.

This *unusually* high plant efficiency, this *unusually* low retardation, might be explained by the fact, that the motor is synchronous and the field fed by rectified alternate currents, that only the self-induction of the armature is in circuit, and the field adds no self-induction whatever. Furthermore, that the frequency used in these motors, 42 periods per second, is somewhat less than the one third of the frequency of our American alternators. If this current were a complex harmonic, we would have in the main wave 26 degrees retardation, and 90 per cent. plant efficiency, that is, the intensity of the current would be 90 per cent. of that value it would have with no self-induction present. The second harmonic has only the plant efficiency of 72 per cent; the third harmonic of 57, the fourth of 47, the tenth only 20 per cent., that is, is decreased to 20 per cent., while the first wave is decreased only to 90 per cent. Hence, even in a motor circuit of such unusually low self induction, if a wave of shape Fig. 8 is applied, it will come out entirely broken up, so I do not think that really the self-induction can be neglected. The more, as just the first term R is small, because we do not want to have the resistance of the circuit large, for the resistance determines the loss of power, and we do not want to have so much loss of power. We want to run motors with these currents. Indeed, if we run a motor from this alternating current we get a counter-electromotive force in the motor, and to make these same equations hold we might represent this counter-electromotive force by apparent resistance. But in such a motor the counter-electromotive force is not of equal phase with the current, but lags behind the current the more, the lighter the load and will come nearer in phase to the phase of the current when we increase the load. Hence the apparent inductance is not even a constant, but a variable of the circuit, and exceedingly variable, too. The inductance is small, almost *nil*, if the motor is at rest under full head of pressure. As soon as the motor starts, its self-induction increases, up to a value which corresponds to the load the motor is carrying, so that if the motor is heavily loaded, the inductance is *comparatively* small, though very far from negligible, while, when the motor is running light, its self-induction increases to such a value as to almost entirely shut off the current.

Now, I come to the consideration of this quantity (L-M). This quantity is really nothing but, or rather proportional to that amount of magnetism, or that magnetism

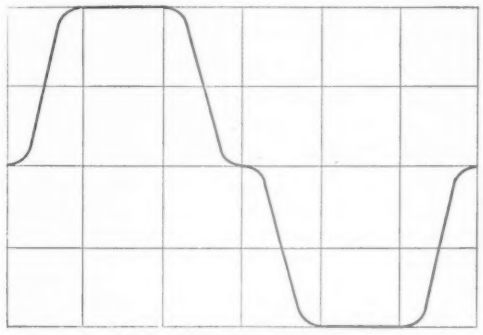


FIG. 1.—STEINMETZ'S DIAGRAM.

which constitutes the rotating magnet poles. So if the motor is at rest, heavy eddies in the short circuit armature circulating coils, the useful magnetism is almost *nil;* almost no magnetism passes through the armature. Hence L is almost identical with M. The circuit has almost no self-induction. If the motor starts, runs with heavy load, then a certain amount of magnetism passes through the armature. L is different from M. L has increased; and we get a difference of phase of the current and a different shape of the current wave. Now, suppose the motor runs with almost no load, then the self-induction of the motor is very large and we can neglect R, the *first* term *entirely!*

In this case the original shape of the electromotive force curve is entirely broken up and has changed into a somewhat harmonic shape. So I cannot think there is any hope to transfer any other shape of the curve but a simple harmonic, through a circuit of heavy and very variable self-induction. That would be rather disappointing and very disagreeable for the builders of motors if the working of such rotary motors would depend upon a certain shape of alternating current waves. Indeed, we all have heard and read half a dozen times—some of us even oftener—how bad and worthless the Tesla motor is, because there the fluctuations of the magnetism amount to, I believe, 41 per cent., and how grand and beautiful the improvements of Mr. Dolivo von Dobrowolsky are, because in his motor the fluctuations amount only to 14 per cent., and if, having heard and read something very often proves its truth, then it must certainly be true. At least this statement about the fluctuations of the intensity of the rotary magnetism seems generally to have been accepted as true. For I never heard any doubt expressed on the correctness of this fluctuation theory. And, nevertheless, in the very first publication of Ferraris on rotating magnet-poles, in the very publication which introduced his rotary magnetism to the public, years ago, it has been shown that if you sent two alternating currents one lagging behind the other by one-quarter of a period, through two coils at right angles with each other, those two currents produced in the center of those coils a magnetic field which revolves with *constant strength* and *constant speed* (See Fig. 2.)

Let A in Fig. 2 represent the one, B the other one of the two perpendicular coils, which are excited by two alternating currents of 90 degrees difference of phase. Then the magnetism produced by coil A at any time, t, can be represented by the line:

$$Om_1 = M \sin \varphi$$

the magnetism produced by coil B at the time, t, is:

$$Om_2 = M \cos \varphi$$

where:

$$\varphi = \frac{2\pi}{T} t,$$

T being the time of one complete period.

These two magnetisms, Om and Om_1, combine by the law of *parallelogram*, which as a consequence of the law of *conservation of energy* holds, to the resulting magnetism:

$Om = M$, of constant strength,

at the phase:

$$m_2\ Om = \varphi = \frac{2\pi}{T} t, \text{ of constant velocity.}$$

That means, the *magnet poles revolve with constant strength and constant velocity, produced by true harmonic or sine waves.* (Kapp: Alternate Current Machinery, page 82.)

Coming, now, to the conclusion, we see:

1. It is possible to produce rotary magnetism of constant strength and constant velocity of rotation by means of true sine waves.

2. It is hopeless to try to produce rotary magnetism of constant strength and velocity by means of a particular shape of the wave of electromotive force, because in a circuit of considerable and variable self-induction the shape of the current wave will differ in a considerable and a variable degree from the shape of the electromotive force wave for any shape of the electromotive force but the true harmonic or sine wave.

3. Hence it is more advisable not to build the *generators* so that they produce that shape of electromotive force which, in a particular type of rotary motors, will give magnetism of constant strength and velocity, but to build motors which will give magnetism of constant strength and velocity from true harmonic or sine waves as the only waves which can be transformed, transmitted through inductive and other circuits without changing their shape; to build the rotary motors for sine waves, as the possibility has been shown by Ferraris, and as already in the oldest Tesla motors it evidently has been the aim of the designer. (Applause.)

Dr. Pupin: Mr. Steinmetz went a little beyond the limits of this paper by talking about the motors. I said at the start that I was going to confine myself to the polyphasal generators, and particularly to polyphasal generators which could under certain well defined conditions produce a rotary field of constant strength. I am going to consider in future the question of transformation and the question of rotating field used for driving a motor. Now, in the case that I considered, I simply had an iron ring surrounded by a set of coils and nothing else. I had no motor armature here. In this case L–M could very easily be made small in comparison to R, the resistance, and therefore may be neglected. But you need not neglect it. If (L–M) is not negligible then the magneto-

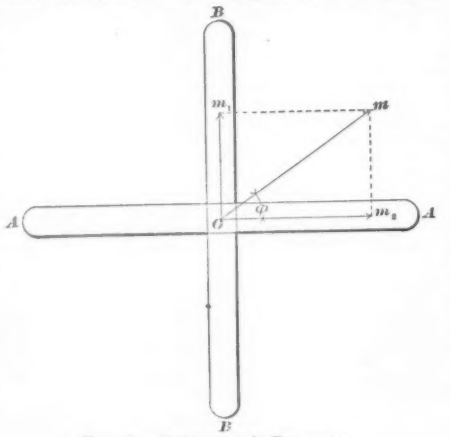


FIG. 2.—STEINMETZ'S DIAGRAM.

motive force will vary, but its variation will be less than 14 per cent. How much less remains to been seen. I don't think that I can show it very well without entering fully into the discussion of the polyphasal motor and transformer. But this subject requires a carefully prepared paper to form a basis on which it can be advantageously discussed. If Mr. Steinmetz will have a little patience I will promise to give him a chance to discuss these things also.

As far as the Ferraris contrivance is concerned, I never saw that paper to which Mr. Steinmetz refers. There must be a hitch in it, I think. Perhaps Mr. Steinmetz will explain exactly the contrivance so that we can see the magnetic circuit and see whether his ideas are correct or not. I know a great many mistakes have been made on this very point of the magnetic circuit; not enough attention was paid as to whether the magneto-motive forces worked in series or multiple arc, nor to the shape and distribution of the magnetic circuits. But, still I would like to know the exact form of the Ferraris motor and the magnetic circuits before I decide to comment upon it.

Mr. Steinmetz: Ferraris built only a little toy, and his magnetic circuits, so far as I know, were completed in air not in iron, though that hardly makes any difference. The only possible error there could be is the use of the law of parallelogram in combining magneto-motive forces acting in different directions upon a point, and this law of parallelogram, or polygon, is a consequence of the law of conservation of energy, and therefore its correctness can hardly be questioned. But as soon as you accept that, then the reasoning I have given here must be correct.* So there is no possibility of any error, if the whole phenomenon takes place in air. Suppose, now, the phenomenon does not take place in air but in any other medium of constant magnetic conductivity, then you have exactly the same conditions. The air-space between armature iron and field iron might introduce some discrepancy, though I hardly think so. But then the next problem would simply be, how to shape the motor iron, how to distribute the wire coils, to get in the iron circuit separated by the air gap the same magnetic distribution as would take place without any iron in the air.

Dr. Pupin: As you have heterogeneous media you cannot have complete homogeneous magnetic circuits and that is where the difficulty comes in. Your parallelogram of magnetizing forces will not apply here and you are forced to be satisfied with the application of Ohm's law to magnetic circuits, which will not give you the result you claimed a little while ago.

Mr. Steinmetz: Consider that wire coils of iron are closely embodied in iron, then there is no question that in the iron the same phenomenon takes place as in Ferraris' experiment in air. So the only problem would be, how to shape the iron practically to get rotary magnetism of constant strength and velocity from sine waves.

This three-phase current system has been brought up in the last time as something entirely new. I cannot agree with that in the least. For already in the old Tesla motor the three phases of current, only that in the three wires that go out from the central station the three currents have not a difference of phase of exactly 120 degrees, but two have a difference of 90 degrees, and either one of these two currents has, with the third, a difference of phase of 135 degrees. But if, now, the "Algemeine Electricitats Gesellshaft" transmits currents of less than 120 degrees difference of phase, well, then, the Dobrowolsky system comes back exactly to the old three-wire system of Tesla, only that the motor is certainly built somewhat differently. But that does not matter. Mechanically the motor is undoubtedly improved, for there are several years' time between the old Tesla three-wire motor and the new German three-phaser. Whether the latter shows any improvements in its principles, is a question which is anything but beyond doubt.

But in the new Dolivo von Dobrowolsky system of electric distribution I really cannot see anything new but the mechanical construction of motors and generators. That it became so famous is, I think, entirely due to the success of the grand transmission of power over such an enormous distance as 116 miles, which cast a halo around everything that was used with this transmission, and so made the rotary motor famous, but in reality I think just as successful, so that the choice of the particular motor had nothing to do with the success of the power transmission.

Prof. Thomson: I should like to make some remarks upon the general subject of the paper. It is a matter to which I have given considerable thought. The subject is somewhat allied to the old Thomson-Houston arc machine. In fact, I remember long ago putting in a patent specification a machine connected so that it had not the three segment commutator, but three rings, and it was rejected at the patent office, on the ground that it was not an invention to put three rings on a three coil armature, any more than it was for any alternating current. But times have changed since then. (Laughter.) It seems to me some light would be thrown on the matter of this discussion by a few simple considerations. We will take the three coil in its simple form—symbols for it, Fig. 3. Now, let us lead off a wire, J, here, which would be a neutral wire. If we wrap that wire around a magnetic core the effect should, of course, be the same, or it should act the same as though these three wires, a, b, c, were wrapped around the magnetic core. So that if any fluctuations of magnetism were set up in this core by wrapping this neutral wire around the magnetic core, the same effect would be produced by wrapping these three wires around the magnetic core. That would show that no fluctuation might be expected in such a system. But there is another question that comes in just here. If we look into the manner of generating; if we take our armature and put on three coils and have a magnetic field which magnetizes this armature core with a constant number of lines, a number of lines which does not change during the rotation, it is evident, then, that whatever actions occur in these coils will be accompanied by no fluctuations of

*Exactly the same conclusion I find now given in Kapp's Alternating Current Machinery, page 82.

magnetism. You cannot generate in a system of coils any difference of condition which is not expressed by the magnetic field in which it is generated. If the magnetic field is constant, then we have constancy of magnetism in the core. That is, we have no fluctuations. Now, it would seem to me, looking at it from this standpoint, that putting another armature in connection with these corresponding terminals and having a magnetic field for it of constant strength, we would have a rotating field produced in this second armature which would result in the rotation of the armature itself; that is, the tendency to rotate the field would turn the coils backward, and this would seem to indicate that under certain conditions we can, with the ordinary arrangements, produce exactly what we want, steady rotative effect without magnetic fluctuations which would go to bear out the Ferraris idea. Now, how far the production of a rotating magnetic field in the presence of a short circuited armature may modify these conditions I have not investigated. It does seem to me, however, that in such case the remarks of Mr. Steinmetz are quite true, that we will have a large self-induction on a light load in such a motor, and therefore a waste current—a leakage current corresponding to the leakage current in the transformer. Just how much it will be, will, of course, depend on the general design and the proportions, and, of course, on the frequency of the alternations. I think the system demands that the frequencies shall be much less than we are accustomed to use in transformers for lighting. That the system will have a considerable application, I have not the slightest doubt. It will have a large application. Whether the best form of it is not to place two corresponding armatures in fields, or use synchronizing machines, is a question. I should say, reasoning at the start, that this is probably the chief merit of the system. We have the possibility of getting rid of commutation on high potential transmission of power by making corresponding machines and running corresponding armatures in fields that are excited. Of course, there is a great desire to get a motor which shall enable us to get rid of this constant excitation, and which will give us the power of starting under load. The generator reversed, and used as a motor, demands that in starting the generator shall also start, that the two machines shall come up together. I have, indeed, taken one Thomson-Houston arc machine and put on three rings, and simply delivered the current by three rings to the armature of another machine, and it would start and run up to speed having no load on it, at least no large load. It would get into synchronous rotation when the power delivered is, after exciting the field fully, considerable. I have constructed some small machines which are almost exactly like Fig. 10. There are six coils on the armature and a field excited separately. The field, by the way, rotates, and the angle covered by the field poles is about what is covered there, Fig. 10. I have no indication at all of anything wrong with these machines. They work, we think, perfectly, and so far as the heat generated in the armature goes, it is remarkably small. It is no greater, from actual experiment, than one would expect from an ordinary machine with a commutator. In fact, it is probably less. Probably more fluctuation is introduced into the magnetism by the commutation than there would be in this case by the simple use of three coils without commutation. I would say, further, that I have never had much confidence in some of the reasoning of Mr. Dobrowolsky in relation to this matter. I have always thought that he was a little out in his argument. He has attempted to show how, by using three-phased currents, he could get polyphasal currents from them, by winding the armature in a different way. It strikes me as nothing more than spreading that coil over a certain angle of the armature surface. This, of course, would prevent sudden sharp jumps in the field, and might be useful, and undoubtedly is useful, in the perfection of a motor working upon a closed circuit armature. These matters of discussion would undoubtedly be best settled by a simple experimentation on the basis of what I indicated a little while ago. It may be that the very fact of the differences of composition of the wave may make a very great difference in the effect. We may not be called upon to reason upon fluctuations of magnetism due to sine curves when those sine curve currents are put in different angular positions. They may act, as in that Ferraris affair, to balance each other, and oftentimes these considerations escape us.

I would say that there is another matter which probably ought to be taken into consideration; that is, that a mass of iron does not always change its magnetism when you think it ought to. That is, it may hold up by its own inherent property of disregarding reversal by hysteresis. This would tend, in fact, to hold the magnetism up rather than to allow it to suffer fluctuation. We know that in a closed circuit transformer it is necessary to put energy into the iron to cause it to drop its magnetism. It would tend to remain magnetized if we cut off the current at any portion of a wave, at least up to a certain point, and this would tend to help us out in this very matter of getting rid of fluctuations of magnetism, which, of course, would be a serious loss of energy in the case of large bodies of iron, the magnetism of which should be allowed to go up and down through large ranges. There is another matter, too, that comes in here; it is whether we get in the motor or in the machine a motion that is equal velocity, that is, whether it is an even pull all the way around, the sum of the magnetic lines being the same, or whether it is a jerky motion, a motion of difference of velocity. Of course, it will naturally be seen at once that unless we get a perfectly uniform flow, our efficiency could not be as high in the case of a fluctuating movement of the lines and the lines which hesitate and then move forward and then hesitate again and then move forward, that would be only efficient in case the armature was negligible, which, of course, could not be the case.

Mr. C. S. Bradley: Did I understand Prof. Thomson to say that he thought the increase of the phasing by Dobrowolsky's plan was applicable especially to the closed armature?

Prof. Thomson: No; I made no distinction between the kind of armatures. I simply say that Dobrowolsky's plan of multiplying the coils and connecting them up did not differ much, so far as I could see, from simply spreading those coils on the armature.

Mr. Bradley: I understood you to say at the last that it applied especially to the closed circuit armature.

Prof. Thomson: You mean by closed circuit armatures, closed field and with connections taken out and around?

Mr. Bradley: Yes.

Prof. Thomson: No; I did not make such a distinction. I should say that the closed

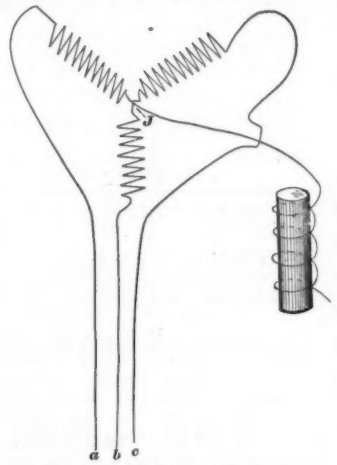


FIG. 3.—THOMSON'S DIAGRAM.

circuit here would be just as effective for getting the polyphasal circuit, provided the coils do not cover too large an angle.

Mr. Bradley: It is a pretty difficult thing to make a test as to the efficiency of the different armatures. But I have always had an idea that the closed coil armature was exactly adapted to the carrying out of the three-phase, because the currents can pass in more directions. There are more subdivisions than there are in the open circuit; with three open coils the position of each would determine its phase. But if it were completely closed and taken out at three points, there is a chance for two wires to operate and leave the third one *nil*, and the current has a chance to pass clear around the armature. That is, it will pass 120 degrees on one side and 240 degrees on the other side, making a multiple arc circuit. In other words, the closed coil armature carries out the plan that Dobrowolsky is trying to carry out, and does exactly what Dobrowolsky is trying to do by placing on the extra coils, without the extra coil.

Prof. Thomson: I think that matter is made clear by considering the movement of the armature with respect to the lines. It does not seem to me to make very much difference what the coil is, providing the two armatures—suppose we take that as the typical system—the two machines are connected similarly. The movement of lines in one will be reproduced in the other, provided, of course, that order of the connections and the symmetry of the apparatus are preserved.

Mr. Bradley: I tested machines running that way. They were direct current machines altered to the three rings. I took them first and ran them as direct current machines. Then I had them changed and put three rings on each one and connected them up and ran them together with the same power and took off the same power, and I found the machines ran so near alike that I could not detect the difference. By the way, in your speaking of two machines you have not at any time said motor and dynamo.

Prof. Thomson: I, of course, meant motor and dynamo. It might interest the members for me to say that at one time, I think it was about 1882, I happened to have a three coil arc machine that had three rings on the shaft, and I discussed with my assistant, Mr. Rice, who is now superintendent of the Thomson-Houston works, this matter of connecting on three rings on two machines, and we found that the machines would work well as a means of transmitting power. But we had not facilities for building such apparatus in in any quantity. However, it is an interesting reminiscence as coming up at this time.

Mr. Steinmetz: With regard to the spreading out of the coils on the armature, I think this makes very little, if any, difference in the shape of the wave, because if we had a coil of one single turn we would get a simple harmonic or sine wave where the maximum electromotive force = 1.414, the effective electromotive force. Now, only a few days ago, I had occasion to draw the curve of electromotive force under exactly the opposite conditions, the most extreme case of spreading out the coils. A smooth continuous current armature changed into a bi-polar alternator by connecting two opposite commutator bars with sliding rings, and I found as ratio between maximum electromotive force and effective electromotive force, 1.415, that exactly the same value as the sine wave gives. I found a wave somewhat similar to the sine wave, slightly different, with a tendency to the shape that Dr. Pupin showed us here in Fig. 8.

Professor Thomson: In making the remark as to the covering of the coils, I meant a motor with a closed circuit armature—not in relation to the generation of the current.

Mr. Kennelly: This is a paper which I think has to be studied from two points of view. Like all mathematical papers, it presents two different aspects. We are face to face with a condition in the art of electrical distribution which is not only somewhat novel, but is also very intricate, and consequently any assistance, even of the most elementary description, which will enable us to fathom the mysteries of this difficult system of distribution is one which should be only too gladly welcomed, I think, at the hands of this institution. We have presented to us in this paper a mathematical disquisition on the very simplest and most elementary type of the three-phase generator, in which it is assumed that there is no armature reaction, no hysteresis, and no eddy currents. Under those conditions, just as in the corresponding ideal transformer, with constant coefficients, which has been called by some one the "phantom" transformer, that we all aspire so much after but so very seldom see—the fundamental operations of this particular machine are readily capable of being analyzed by the skill that has been presented in this paper. I think that we should be content to take one subject at a time, to consider that we have arrived at a position where modifications, which will certainly present themselves by disturbing influences, will ultimately resolve themselves into this fundamental type, as they are lessened and removed. This is the starting point, so to speak, from which the various roads branch from the theoretical machine to the practical machine. I think, therefore, that while the paper gives us what may be called almost a little discovery in its way in practical mathematics, that it should be treated for its own value on the side of a mathematical essay and not brought into the question of practical and every-day machines. We have the very remarkable fact that, although the electromotive force, which is capable of being produced by a complex condition of magnetic fields, can be a uniform one, and while the currents which are set up by the electromotive force cannot possibly be the prototype of the electromotive force, graphically, when there is any self-induction in the circuit, yet that under the influence of mutual induction that prototype may be restored. That is a beautiful conception, even although it may not have a very direct bearing on the practical side of the question. It seems to me that the practical issue of the question is not whether we can produce artificially and with considerable care a constant rotary magnetic field or a constant rotary electromotive force, for by theory we can produce any continuous curve, and any periodic wave can be established as the resultant of a number of simple harmonic waves; it only is a question of how many compounds we want. Sometimes we should want a infinite number. But however interesting that may be from the theoretical point of view, the next step in this difficult pathway which has been outlined here to-night is not how to produce perfection, but how far differences from perfection will affect the practical result; not how necessary it may be to have a perfectly continuous field, but how far the fluctuations, which will almost inevitably present themselves, will affect the efficiency and efficacy of these particular machines. At the same time, while we have to remember that the paper is a theoretical disquisition, it is also the first step towards practice, because theory follows ever slowly in the steps of practice, and it is in the direction of such theory that we have to hope for the ultimate apprehension of all the difficulties before us.

Dr. Pupin: The method which I have employed, as Mr. Kennelly remarked, is to go step by step from the ideal to the more and more practical and see what the real difficulties are. Now, as long as we deal with simple harmonic waves, the question is exceedingly simple and is readily solved. The authorities on theoretical electrical engineering invariably consider the simple sine waves whenever they discuss the subject of periodically varying electric currents. Nobody has ever tackled the problem of complex harmonic waves. We really do not know what a complex harmonic wave will do. We can only guess at it. There are no quantitative relations. Now, I think that I have shown in this paper what a complex harmonic current wave will do in a particular case. I also propose to show before long what it will do in other practically important but more complicated cases. Mr. Steinmetz points out that a combination of two simple sine waves can produce the same thing which I claim for the complex wave. But the correctness of his statement requires the employment of a homogeneous magnetic medium in which his two coils are to act. I would be very much obliged to him for the proof of the contrary.

The remark of Prof. Thomson with reference to the machine which he put on the blackboard, three coils rotating in a uniform field, has been answered in the very beginning of my paper. They will produce a constant rotary field, although the producing field, the exciting field, is constant. The relation of the coils with respect to the exciting fields is continually varying, and the electromotive force produced in each one of those is a simple sine wave, and as long as we have simple sine waves and three phases, there will be a maximum variation of 14 per cent., no matter what you do. Now wind the three wires on a piece of iron. The neutral wires will produce no magnetization. The three wires, if they are wound around the same coils in the same way, will also produce no magnetization, so I do not think that the experiments suggested by Prof. Thomson could give us any record of any fluctuations in the rotary field. With respect to the production of that particular wave, Mr. Steinmetz remarked that it is impossible to produce anything like it. Of course, in nature there are no discontinuities. Nature hates discontinuity, and there are no absolutely discontinuous functions. Here you see (Fig. 8) the tangent is continually constant at all points until the corner is reached, when the tangent suddenly becomes zero. This discontinuity is, of course, physically impossible, but in practice we can come as near to it as we choose to do, if we care to take the trouble. Of course, we would employ a practically discontinuous field. That is, you are in a place where there are lines of force, and suddenly you step into a place where there are practically no lines of force. Now, absolutely that is impossible. But we can come as near as we choose to by simply shaping the magnetic circuit in such a way that it will be nicely rounded and allow the lines of force of the magnetizing coils to follow it without getting too much out of their way. If you do that, then there will be practical discontinuities. Now, I have an electro-magnet which will do that very nearly, where the lines of force of the magnetizing coils never deviate too suddenly from the magnetic circuit, and, therefore, there is very little leakage. I hope at some future time to show before the Institute this electro-magnet. It is a very simple device. I do not say that I can produce that electro-magnet without sacrificing several practical advantages. But if it is only for experimental purposes, I do not care if I do sacrifice them. I dare say I will not rest until I get that electromotive force given in Fig. 8, plotted on paper from experimental results. But it is very difficult to do anything in New York in a hurry, because mechanicians will not attend to their orders when you wish them, and you have to wait for them. As Mr. Kennelly remarked, I do not think it is time yet to consider what will take place when we apply this rotary field to drive a motor, because I wish to limit the discussion to the limits of the paper.

Mr. Steinmetz: With regard to this Ferraris scheme, I only wanted to show that, under certain conditions, a rotary field can be produced by sine waves of electric current. Suppose you have two equal coils at right angles with each other, entirely embedded in iron. The armature of the Pacinotti, or a similar type, with a very small clearance between armature iron and field iron, so small a clearance that the air reluctance can entirely be neglected against the reluctance of the iron; then you have exactly the conditions where you get from two sine waves of 90 degrees difference of phase a system of magnet poles which revolve with constant intensity and constant velocity.

The Edison Electric Illuminating Company, of Rochester, N. Y., recently declared a semi-annual dividend of three per cent.

KINDRED INTERESTS

W. C. Leete has purchased the Syracuse Electric Manufacturing Company's business and took possession on the first of the month.

The W. T. C. Macallen Company, Boston, report that the McCarty insulating joint, recently illustrated and described in the REVIEW, is meeting with ready favor at the hands of buyers.

The Joseph Dixon Crucible Company, of Jersey City, have issued a neat pamphlet descriptive of the various styles of pencils, crayons, etc., manufactured by them. It is a long list.

Dravo & Black, Pittsburgh, Pa., are installing at the Pittsburgh Plate Glass Company, Ford City, Pa., two 150 horse-power tandem compound engines built by the Ball Engine Company, Erie, Pa.

The Ongley Electric Company, No. 1 Broadway, New York city, send us a pamphlet descriptive of its protective electric system and watchman's register. It is nicely gotten up and very clear in its explanation.

The Electric Merchandise Company, of Chicago, Ill., informs us that the suit of Chas. A. Lieb, instituted against them several months ago for infringement of a patent on rail bonds, has been decided by Judge Blodgett, strongly in their favor.

The Electric Gas Lighting Company, 195 Devonshire street, Boston, have published for the new year, as usual, a very complete and tasteful catalogue of their numerous specialties, etc. The cut on the cover is typical of the pace of this enterprising firm. Send for it.

The Eickemeyer-Field Company, Yonkers, N. Y., has issued a most interesting and well prepared pamphlet describing the Eickemeyer-Field street railway apparatus and the Eickemeyer dynamos and motors. The pamphlet bears the imprint of The James Kempster Printing Company, New York.

The passenger department of the Chicago, St. Paul and Kansas City Railway Company has just issued a quite elaborate flyer printed in colors, with a number of half-tones of scenery along the route. It is printed in connection with the annual meeting of the National Educational Association, to be held in Saratoga, July 12–15, this year.

The New York Belting and Packing Company (Limited), 15 Park Row, New York, are distributing among their friends and the trade a very neat and convenient six-inch vest-pocket rule. It bears upon one side the name of the firm and calls attention to their vulcanized rubber belting, packing and hose, and vulcanite emery wheels.

The Central Electric Company, Chicago, have ready for distribution a handsome lithographed circular of the Bryant specialties, which have earned such a well deserved reputation. They are also sending to their friends a handsome calendar for 1892, and will be glad to hear from those who are not supplied so that they can be furnished.

A. B. C.—We are in receipt of a very effective New Year's Souvenir from the enterprising house of Alexander, Barney & Chapin, in the form of a handsome four page pamphlet from the press of Messrs. Bartlett & Company. It is of very original design and conveys to their friends *and enemies*, if they have any, the most kindly sentiments. The same in return Messrs A. B. & C.

The Mather Electric Company, of Manchester, Conn., have just closed an important power contract for the new building of the Van Platz Brewery, of Milwaukee. The brewery intends using no other power than electricity in the future, and the Mather Company will install 350 horse-power in generators and 23 motors with a total capacity of over 400 horse-power. The plant is to be in full operation by May.

The New England Printing Telegraph Company, of 99–101 Milk street, Boston, announce that on and after January 4 the company will do a regular telegraph business between Boston, Providence, Woonsocket and Danielsonville, over its own lines, which have just been completed. The offices are located at 99–101 Milk street, Boston, No. 19 South Water street, Providence, the office of the *Woonsocket Reporter*, Woonsocket, R. I., and Quinebaug store, Danielsonville, Conn. Messages to be delivered throughout these cities by messengers. Tariff rate, 15 cents for 10 words and one cent for each additional word.

The Tropical American Telephone Company, Limited, has taken the agency of the Viaduct Manufacturing Company, of Baltimore, and will keep a line of goods of this company's manufacture in stock at No. 95 Broad street, New York, both for export and United States trade, consisting of: District telegraph boxes, under U. S. patents; magneto fire alarm system, under U. S. patents; fire alarm boxes and tower strikers; magneto call bells, with patent telephone hooks; magneto power generators, under U. S. patents; extension bells and magneto bells; still burglar alarms, under U. S. patents; dial telegraphs, electric push buttons; visual annunciators for call boxes; electric lamps and incandescent lamp trimmings, electric thermostats; storage battery fixtures, dynamos and general brass and fine wood work for electrical apparatus of all kinds. The Viaduct Company owns and controls a number of important United States patents, covering many of the foregoing articles and has a large well-equipped factory run by water power, at Relay House station, of war-time fame.

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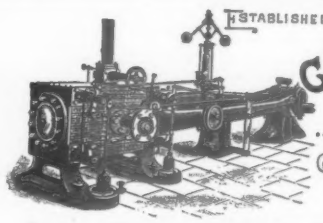

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ELECTRICAL PATENTS

INDEX OF INVENTIONS FOR WHICH LETTERS PATENTS OF THE UNITED STATES WERE ISSUED ON DECEMBER 29, 1891.

466,028 Governing device for electric motors; William Baxter, Jr., Baltimore, Md.

466,037 Electrically operated elevator; Frank E. Herdman, Indianapolis, Ind.

466,052 Electric plug circuit closer; James L. Kimball, Boston, Mass.

466,053 Electric signaling apparatus; Bernice J. Noyes, Boston, Mass.

466,058 Electric game register for pool tables; Carl A. Erikson, New Britain, Conn.

466,063 Electric annunciator; Frank C. Colville, Oakland, Cal.

466,086 Mechanical telephone; Henry B. Thompson, Pittsburgh, Pa.

466,087 Temperature regulating device for electrical circuits; Edward Weston, Newark, N. J.

466,101 Electric railway switch; Max Kerstein, Boston, Mass., assignor of two-thirds to Henry Cramer and Robert Fabery, same place.

466,131 Art of and apparatus for heating metal articles by electricity. 466,132 466,133 Electric forge; Edwin E. Angell, Somerville, Mass., assignor to the Electrical Forging Co. of Maine.

466,138 Secondary battery plate; Henry G. Morris and Pedro G. Salom, Philadelphia, Pa.

466,159 Annunciator; William C. Dillman, Brooklyn, assignor to Owen Walsh, New York, N. Y.

466,177 Galvanic battery; Samuel Miller, Buxton, England, assignor to Evelyn Glover, same place.

466,180 Electrically driven locomotive; Everard H. Morgan, Dover, England.

466,196 Electric railway trolley and support; Wilbur A. Stevens, Kansas City, Mo.

466,212 Electric car brake; La Motte C. Atwood, St. Louis, Mo., assignor to the Atwood Electric Co., East St. Louis, Ill.

466,244 Electric switch. 466,245 Controlling apparatus for incandescent lights; William J. Kelley, Boston, Mass., assignor to John P. Cushing, same place.

466,250 Electric conductor; Joseph W. Marsh, Pittsburgh, Pa., assignor to the Standard Underground Cable Co., same place.

466,266 Electric heating tool; George W. Blanchard, Waterville, Me., assignor to the Electrical Forging Co. of Maine.

466,268 Electric cable; William A. Connor and Joseph W. Marsh, Pittsburgh, Pa., assignors to the Standard Underground Cable Co., same place.

466,306 Electric fire alarm system; Henry E. Jacobs, Milwaukee, Wis., assignor to Frank G. Bigelow, Moses H. Brand and George Knowles, Jr.

ISSUED JANUARY 5, 1892.

466,357 Electric annunciator; Charles Molitor, Chicago, Ill.

466,362 Electric railway crossing; William Osner, Chicago, Ill.

466,367 System of electric distribution for railways. 466,368 System of electric distribution for moving translating devices; Nelson W. Perry, Cincinnati, O.

466,391 Insulator; William S. Andrews, New York, N. Y., assignor to the Edison General Electric Co., same place.

466,400 Cut-out for incandescent lamps; Thomas A. Edison, Llewellyn Park, and John F. Ott, Newark, N. J., assignors to the Edison Electric Light Co., New York, N. Y.

466,427 Extensible electrical conductor; Benton C. Rowell, Boston, Mass., assignor of one-half to D. Howard Vincent, same place.

466,447 Device for electric elevators; Rudolph C. Smith, Yonkers, assignor to Otis Brothers & Co., New York, N. Y.

466,448 Commutator brush and holder for dynamo-electric machines and motors; Frank J. Sprague, New York, N. Y., assignor to the Edison General Electric Co. of New York, N. Y.

466,460 Art of electrolytic decomposition; Thos. A. Edison, Menlo Park, N. J.

466,471 Underground conduit for electric railways; Charles P. Tatro, Spokane, Wash.

466,492 Cable telegraphy; Wilson E. Facer, Cleveland, O., assignor to George S. Iddings and M. M. Hobart, same place, and George N. Morton and S. W. Wood, New York, N. Y.

466,505 Combined electrical protective and time detecting system; James S. Morse, New York, N.Y.

466,508 Electric switch. 466,509 Electric drop light. 466,510 466,511 Electric lamp socket switch; Gwynne E. Fainter, Baltimore, Md., assignor of one-half to James F. Morrison, same place.

466,513 466,515 Ore separator. 466,514 Ore separating machinery; Charles J. Reed, Orange, N. J.

466,518 Apparatus for synchronizing clocks; Ludwig Von Orth, Berlin, Germany.

466,519 Circuit controller; Henry P. White, Kalamazoo, Mich.

466,539 Car truck for electric railway cars; Peter M. Kling, St. Louis, Mo., assignor of one-half to Edmond Verstraete, same place.

466,541 Electric reciprocating tool; Harry N. Marvin, Syracuse, N. Y., assignor to the Marvin Electric Drill Co., same place.

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